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Cover: Eastern Fox Snake (*Elaphe vulpina gloydi*) photographed by P. M. Catling near Amherstburg, Ontario, May 1976. See articles on pages 19 and 28.

The Canadian Field-Naturalist

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Characteristics of a Population of Muskrats (*Ondatra zibethicus zibethicus*) in New Brunswick

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Muskrats (*Ondatra zibethicus zibethicus*) in southeastern New Brunswick were studied from spring 1976 through fall 1977. The spring and fall harvests favored males, the 2-yr spring and fall male:female ratios being 121:100 and 144:100 respectively. Males were more abundant in the juvenile cohort. The ratios of juveniles to adults in the fall harvests of 1976 and 1977 were 3.5:1.0 and 5.0:1.0, respectively. Placental scar counts of fall-caught adult females from 1976 through 1978 gave a mean count of 17 (range 12–24). The mean number of litters per adult female was estimated at 2.5 with six to eight kits per litter. The mean weight gain for juveniles through their first summer was 10.7 $g \cdot d^{-1}$ for males and 6.7 $g \cdot d^{-1}$ for females. Extensive seasonal or annual movement by Muskrats was not documented, although considerable local (< 200 m) movement between habitat types occurred in late winter or early spring.

Key Words: Muskrat, New Brunswick, harvest statistics, *Ondatra zibethicus*, population characteristics, seasonal variations, population structure, growth, reproduction.

In recent years the Canadian Wildlife Service (CWS) has established National Wildlife Areas across southern Canada to protect and manage wildlife habitat. Some of these tracts are wetlands in which water levels have been manipulated to encourage their use by waterfowl. In the Maritimes ditching and the construction of dikes and water-control structures have usually been undertaken through the cooperative assistance of Ducks Unlimited (Canada) and developed in coordination with a National Wildlife Area Management Committee.

Such management has greatly increased the value of these lands for waterfowl. An indirect benefit of marshland management is the improvement of habitat for Muskrats (*Ondatra zibethicus zibethicus*). Although the effects upon Muskrat populations are assumed to be positive, no studies had been specifically designed to monitor Muskrat populations during and following habitat modifications on National Wildlife Areas. The dramatic increase in the monetary value of Muskrat pelts over the past several years has increased the demand for this furbearer. Consequently, the importance of managed marshlands to Muskrats, relative to waterfowl, has grown over the past few years.

In 1976 CWS began a study to evaluate the effects upon Muskrats of impoundment management for waterfowl on the Germantown Marsh in the Shepody National Wildlife Area of southeastern New Brunswick. This paper presents data collected during the first two years (1976–1977) of study on Muskrat densities, seasonal movements, growth rates, and sex and age structure. Some additional information on productivity is included from the 1978 fall harvest.

Study Area

The Germantown Marsh is located in Albert County in southeastern New Brunswick (Figure 1). It is the first of several wetlands that will eventually form the Shepody National Wildlife Area. Purchase of the Germantown Marsh was nearly completed in 1973, a management plan was conceived in 1974, and construction and modifications by Ducks Unlimited began in 1975. Of the eight impounded areas, one was flooded in 1975, one in 1976, and the remainder in 1977.

The completed project leaves the marsh with the narrow Shepody River bisecting the area and serving as a drainage channel for adjacent impoundments. The extent of impoundments, woodlands, natural marsh, and drained marsh is approximately 350, 140, 120, and 55 ha respectively, for a total of 665 ha. Only the impoundments and natural marsh (470 ha) and the narrow Shepody River can be considered Muskrat habitat.

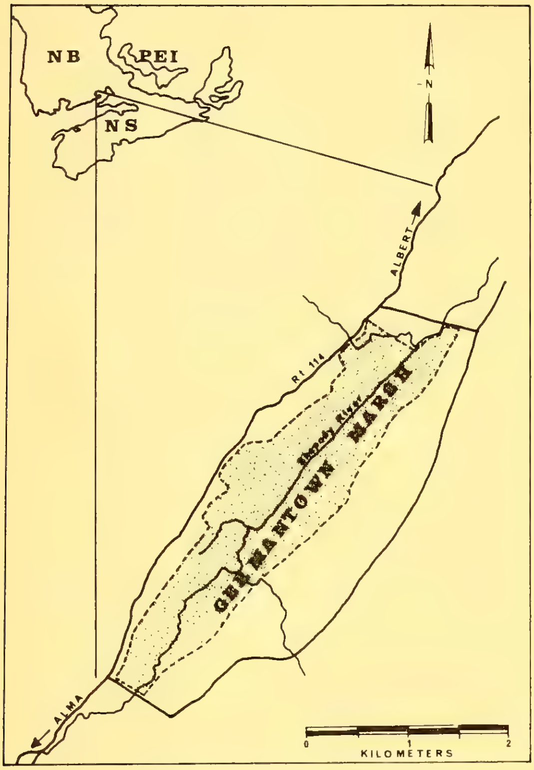

FIGURE 1. Location of the Germantown Marsh in southeastern New Brunswick where Muskrats were studied.

Methods

In the spring, summer, and fall of 1976 and 1977, Muskrat lodges were surveyed with a Bell 206 Jet Ranger helicopter. The helicopter was flown at slow speed 30–40 m above the ground and lodges were examined visually to determine whether they were currently being used by Muskrats. Lodge distribution was plotted on aerial photomosaics (scale: 1 cm = 385 m).

Muskrat trappers were informed of the program and all Muskrats harvested from the study area during the spring and fall trapping seasons in 1976 and 1977 were recorded by trapper, date, location, sex, age, weight, and length. Reproductive tracts were removed from adult females in the 1977 and 1978 harvests.

We began a live-trapping program at the closure of the spring trapping season and continued until the fall season in both years. Havahart live-traps were tried with only marginal success and were soon replaced with the double-door Tomahawk live-trap (Tomahawk Live Trap Co., Tomahawk, Wisconsin), which improved our success. The study area proved so large, and mobility so difficult, that a system of uniform trapping pressure throughout the area over the summer was impossible. Various parts of the channel were trapped throughout the summer; some impoundments were re-trapped as the summer progressed. Most areas were trapped until few new animals were caught; traps were then moved to another site.

Muskrats were normally subdued by the drug ketamine, using a concentration of 10 mg/ml and dosages ranging from 0.5–0.8 ml depending upon the size of the animal. New Muskrats were weighed, sexed, aged, and tags (monel metal #3, National Band and Tag Co., Newport, Kentucky) placed in both ears.

Results

Lodge Counts and Live-trapping

Six aerial surveys were flown during spring, summer, and fall of 1976 and 1977 to locate and plot the distribution of Muskrat lodges. The spring and summer surveys recorded the distribution of Muskrat lodges relative to impoundments and natural marsh. The fall surveys, which were flown after the first ice but before extensive snowcover (1 December 1976; 30 November 1977), recorded the distribution of lodges and served as indices to the fall population. Because of the intensive and systematic method of searching, we are confident few lodges went unrecorded.

Summer lodge counts in 1976 and 1977 were 26 and 30, respectively, whereas fall counts were 96 and 97, respectively. Spring counts showed great variation because of high water and flooding conditions. The similarity of the two summer lodge counts and of the two fall counts suggests that the population experienced little change over the 2-yr study period.

Although the total count of lodges remained constant between years, their distributions showed considerable variation because of man-induced changes in the habitat. Throughout the study, impoundments were being constructed, flooded, drained, and reflooded. It appeared some Muskrats actually retreated to the more stable natural marsh where lodge counts were greater in the fall of 1977 than in 1976 (38 vs. 31). Only the first impoundment flooded in 1975 contained a high concentration (22) of houses in the fall of 1977.

From 10 May to 22 October 1976, 129 individual Muskrats were live-trapped and there were 162 recaptures. From 24 May to 21 October 1977, these figures were 193 and 141, respectively. The proportions of juveniles in the total first-captures in 1976 and 1977 were 72% and 76%, respectively; the 2-yr mean was 75%. The ratios of adult males to females for those two years were 142:100 and 150:100. The ratios of juvenile males to juvenile females were 175:100 and

251:100. In 1976 trapping success (trap-nights per animal caught) increased from 25.4 in May to 2.6 in late October. In 1977 trapping success increased from 33.3 in early June to 2.0 in late October. There were fluctuations in success through the summer in both years, but the overall increase in trapping success from May to October reflects the continuous build-up in the population resulting from the juvenile cohort. It is interesting to note that in both years trapping success was greatest in the impoundments, followed by the natural marsh and the Shepody River channel. In 1976 juveniles were not captured until July, whereas in 1977 they were trapped throughout June.

Seasonal Harvests

In the spring seasons of 1976 and 1977, 251 and 304 Muskrats were removed from the Germantown Marsh. Muskrats removed during the falls of 1976 and 1977 totalled 60 and 89, respectively (Table 1). The ratio of spring- to fall-caught Muskrats for both years was approximately 4:1. The 1977 harvest showed a 26% increase over that of 1976.

The distribution of the spring harvest among the channel, impoundments, and natural marsh was 29%, 26%, and 45% in 1976 and 35%, 44%, and 21% in 1977. No Muskrats were removed from the natural marsh in the falls of 1976 or 1977. Most were trapped from the impoundments in the falls of 1976 (57%) and 1977 (81%).

The sex ratio of the annual harvest favored males in all seasons, especially in fall when immature males were predominant. The male:female ratios in the springs of 1976 and 1977 were 134:100 and 112:100, respectively. Although sample sizes were small in the fall, the male:female ratios in 1976 and 1977 were 129:100 and 153:100, respectively. The mean spring and fall male:female ratios for both years were 121:100 and 144:100, respectively.

In the spring we did not attempt to distinguish adults from the last year's kits. All Muskrats caught prior to the appearance of kits were classified as adults. We separated adults from juveniles in the fall. The ratios of juveniles to adults in the fall harvests of 1976 and 1977 were 3.5:1.0 and 4.7:1.0, respectively.

Reproduction and Growth

Reproductive tracts from adult female Muskrats trapped in the falls of 1977 and 1978 were retained and examined for placental scars. The mean placental scar count was 17 with extremes of 12 and 24. Those counts suggest that some Muskrats had three litters, with the mean probably between 2 and 3. Using a mean of 2.5 litters per adult female, the theoretical mean litter size was 6.8. The extent of intrauterine loss and early post-natal mortality is not known for certain; however, the ratio of juveniles to adult females in the fall harvests of 1976 through 1978 was 9.3:1.0, suggesting a loss of 7.7 juveniles (45%) from implantation to fall. The extent of rearing success depends upon many complex environmental factors but the rate of rearing success (55%) in the Germantown Marsh must be considered high relative to other published data. Errington (1963) reported summer juvenile mortality as high as 65–70% during unfavorable breeding seasons in Iowa, and considered a rearing success of 55% or greater to represent a high rate of annual recruitment.

The recapture of juvenile Muskrats in both years provided data on individual weight gains throughout the summer season (Figure 2). The smallest Muskrat weighed 200 g when first captured; this is the weight of most juvenile Muskrats when they first leave the nest and begin to travel near the lodge at the age of approximately 30 d (Dorney and Rusch 1953; Errington 1963). This smallest juvenile, a male, was later reweighed in August and September, and showed a mean weight gain of 8 $g \cdot d^{-1}$ from 30–60 d of age and 7.5 $g \cdot d^{-1}$ from 0–60 d. The mean weight gains for all juveniles through both summers were 10.7 $g \cdot d^{-1}$ for males and 6.7 $g \cdot d^{-1}$ for females. This suggests that

TABLE 1—The numbers and mean weights of Muskrats harvested from the Germantown Marsh, spring 1976 – fall 1977

Year, season	Total	Numbers harvested					Mean weight ± SD (g)			
		Adults		Juveniles		Unknown	Adults		Juveniles	
	(n)	♂	♀	♂	♀		♂	♀	♂	♀
1976										
Spring	251	134	100			17	1367 ± 136	1234 ± 152		
Fall	60	4	7	22	17	10	1497 ± 161	1450 ± 179	1083 ± 20	1057 ± 85
1977										
Spring	304	161	143				1366 ± 172	1241 ± 154		
Fall	89	11	4	43	28	3	1469 ± 119	1403 ± 149	985 ± 169	954 ± 184

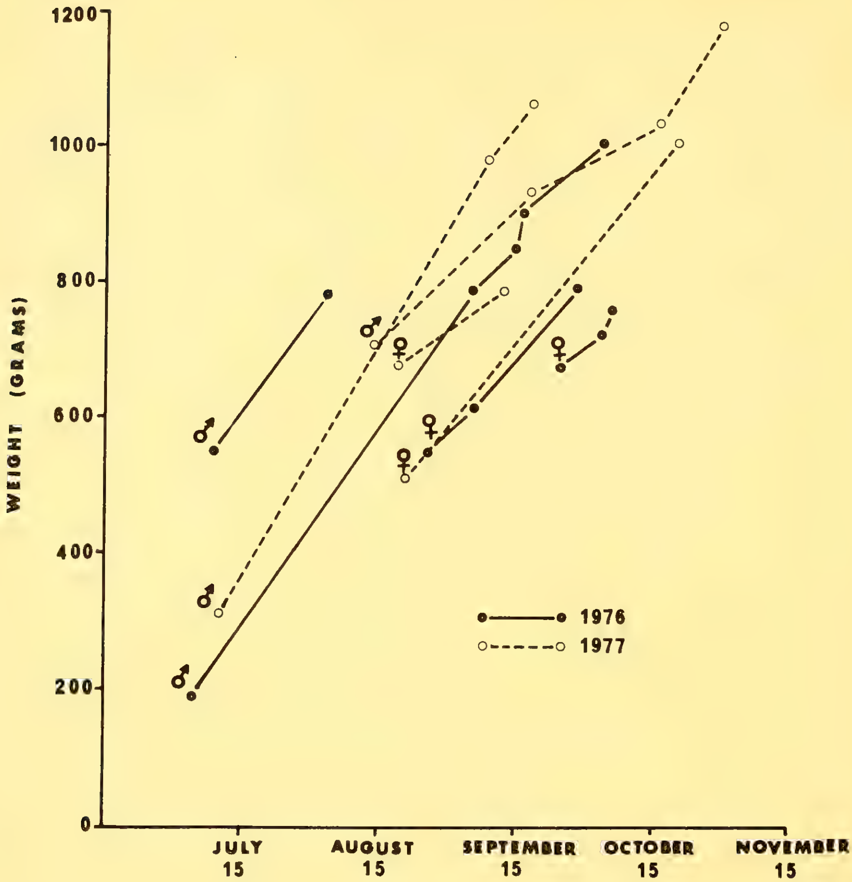

FIGURE 2. Weight gains for individual juvenile Muskrats recaptured in the summers of 1976 and 1977 on the Germantown Marsh.

juveniles increase their daily weight gains with age, as many of the Muskrats weighed over 400 g when first caught.

We estimated birth dates for juvenile male Muskrats captured through the summers of 1976 and 1977 by back-dating calculated daily weight gains. We assumed that at 30 d of age a Muskrat weighed 200 g and then gained an average of 7.5 $g \cdot d^{-1}$ up to 800 g. Juveniles heavier than 800 g were not used in these calculations. To increase sample size we pooled the weights for 1976 and 1977 (Figure 3). Calculated birth dates suggested three peaks in litter production, one in the last two weeks of May, one during the middle of June, and the other during the first two weeks of July. The earliest birth date was the first week of May and the latest was the third week of August.

Adult Muskrats also experienced weight gains through the summers of 1976 and 1977. The weights of live-trapped male and female adults were averaged for the periods May–July, August–September, and October for both years. Both sexes showed progressive weight gains throughout the summer in both years, except for adult females in 1976 when a slight decrease in weight was evident for Muskrats caught in October. Summer weight gains were greater for males than for females, and both sexes showed greater gains in 1977 than in 1976. In 1977, adult males showed a mean summer weight gain of 20.0%; for females, the gain was 12.0%.

Seasonal Movements

Of 322 Muskrats captured and marked, 303 recaptures of marked animals, and 61 tagged Muskrats returned by trappers, there was no evidence of extensive movement, either seasonal or annual, by Muskrats within the study area. No recoveries were greater

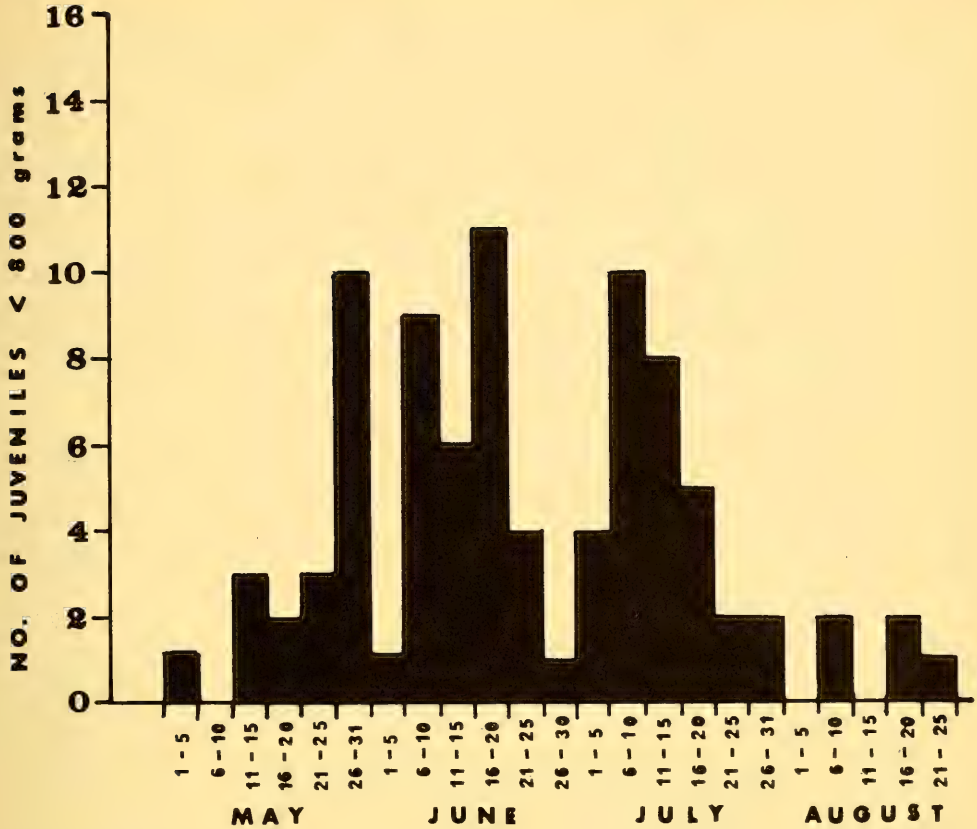

FIGURE 3. Estimated birth dates for juvenile Muskrats (< 800 g) live-trapped and weighed in the summers 1976 and 1977, based upon calculated rates of daily weight gain.

than several hundred metres from the site of tagging and all were within the expected cruising distance. The tagging and recovery program, however, showed that there was a distinct seasonal shift between habitat types by many Muskrats.

Most Muskrats remained with the same habitat type, and within a relatively confined area throughout the summer and fall seasons. All recaptures (n = 162) during the summer and fall (June–October) of 1976 were from the same habitat where first captured. In 1977 when there were 141 recaptures, no emigration occurred from the natural marsh or impoundments, but 4 of 46 Muskrats tagged in the channel were subsequently captured that summer in adjacent impoundments. Only seven ear-tagged individuals were harvested in the fall of 1976; all were trapped in the channel where they had been tagged. Only 1 of 30 Muskrats tagged during the 1977 summer and recovered from the 1977 fall harvest, had moved out of the habitat type where it had been originally captured.

Movement of Muskrats among habitat types seems to occur most readily between the fall and spring periods, probably in early spring when high water forces them from winter lodges and flooded burrows.

Nine of 24 (37%) Muskrats tagged in the summer of 1976 and recovered by trappers in the spring of 1977 had moved from the habitat type where they had been tagged. This movement was distributed equally among all three habitat types, and among Muskrats of all sex and age classes (adult male, 1; adult female, 3; immature male, 3; immature female, 2).

Population Estimates

Several methods of population estimation were used to calculate the seasonal numbers of Muskrats. The fall counts of lodges in 1976 and 1977 showed little change in the number of Muskrats over the 2-yr period.

As public trapping pressure was concentrated in localized areas, population estimates using the Peter-

sen Index could not be applied to the total study area. It was used to estimate the mean number of Muskrats per lodge for specific impoundments. Population estimates for two impoundments in the fall of 1977 were 51 and 65. Lodge numbers for these impoundments were 22 and 10, respectively. The mean number of Muskrats per lodge for these impoundments was 3.5. Extrapolating the mean number of Muskrats per lodge (3.5) to total lodges on the study area (97) provides an estimate of 339 Muskrats outside the channel. Muskrats in the channel live in bank burrows rather than lodges.

In fall 1976, the number of Muskrats in the upper third of the channel was estimated at 68 by the Seber-Jolly method (Ricker 1975) and 92 by the Petersen Index method. In fall 1977, the Petersen Index estimate for the same area was 62. The fall estimate for the upper third of the channel in both years was probably near 75 Muskrats.

The lower two-thirds of the channel supported lower densities as shown by our live-capture success through the summer, and we make the assumption that another 75 lived there, for a total estimate of 150 Muskrats occupying the channel. That estimate, added to the estimated 339 Muskrats outside the channel, provides a fall population estimate of 489 Muskrats within the study area.

In 1977, with more uniformly distributed live-trapping throughout the study area, we obtained a total population estimate using the Seber-Jolly method (Table 2). Disregarding the late September estimate, which was exaggerated owing to live-traps being removed early thereby reducing recaptures, the fall population estimate was 481, very similar to the earlier estimate of 489.

We believe the fall population experienced little change between 1976 and 1977, and the total population on the Germantown Marsh in the fall of both years was approximately 500 Muskrats.

The channel, with an estimated 150 Muskrats, supported the greatest density in the study area. Using the mean of 3.5 Muskrats per lodge in the fall of 1977, the natural marsh supported 1 per 0.9 ha and the controlled impoundments 1 per 1.7 ha.

Discussion

The use of the Tomahawk live-traps for capturing Muskrats is recommended over the Havahart live-trap models. Our success with both the single-door and double-door Tomahawk traps was far greater than that of the Havahart traps. We also recommend the #3 monel ear tags for marking, and the use of the drug ketamine for subduing captured Muskrats. The main source of mortality during trapping was from drowning, normally associated with heavy rains and rapidly fluctuating water levels in the channel area.

Most of the data are new for the Muskrats of New Brunswick, and comparisons can be made with popu-

TABLE 2—Categories of marked and recaptured Muskrats in the Seber-Jolly method of population estimation for the Germantown Marsh, summer 1977

Time	Newly marked (M_i)	Examined for marks (C_i)	Recaptures, marked at time 1	2	3	4	5	6	7	8	9	10	Total (m_i)*	K_i**	B_i***	N_i†
1. 24–31 May	5															
2. 1–15 June	3	4	1										1	5	6	24
3. 16–30 June	13	16		2	1								3	6	11	58
4. 1–15 July	5	9	2		2								4	10	16	36
5. 16–31 July	—	1	1										1	13	1	—
6. 1–15 Aug.	6	8			1	1							2	11	11	44
7. 16–31 Aug.	18	21	1					2					3	15	27	189
8. 1–15 Sept.	35	49	1		3	1		1	8				14	26	165	577
9. 16–30 Sept.	33	42		1	2			1		5			9	18	603	2814
10. 1–15 Oct.	21	25				1		1	1	1			4	7	77	481
11. 16–21 Oct.	23	30				1		2	2			2	7			
Totals (R_i)††			6	3	9	4	0	7	11	6	0	2				

*m_i = Marked Muskrats caught during time *i*.

**K_i = Muskrats marked in population prior to time *i* and subsequently caught.

***B_i = The number of marked Muskrats in the population just prior to capturing the *i*th sample.

†N_i = Population estimate for time *i*.

††R_i = Muskrats marked during time *i* and subsequently caught.

lations in other states and provinces of northeastern North America. The sex ratio of Muskrats in southeastern New Brunswick, as has been demonstrated in most other regions, favors males at all seasons. The proportions of males in spring and fall harvests of adults in 1976 and 1977 were 56% and 54%, respectively. The 2-yr average was 55%. The proportions of males in the fall harvests of juveniles for those two years were 56% and 60%, respectively. The 2-yr average was 59%. Results of the live-trapping program confirmed the apparent preponderance of males in the population. The proportions of males in the adult samples in 1976 and 1977 were 58% and 60%, respectively. The proportions of males in the juvenile samples for those two years were 64% and 71%, respectively.

The percentages for adult males from the live-trapping program are greater than the 55% suggested by Errington (1963) to be the average for most populations, although the mean percentage from the spring and fall harvests is identical. Errington (1963) also found that in Iowa the proportion of males in the juvenile cohort was greater than that for adults, although that figure (55.4%) was considerably less than the 2-yr means from the fall harvests (59%) and the live-trapping program (65%) on the Germantown Marsh. A higher summer mortality for males than females could well account for the lower percentage of males in the fall harvest relative to the summer live-trapping program.

Our data suggest a greater preponderance of males in the population in 1977 relative to 1976, especially in the juvenile cohort. The reason for the apparent discrepancy is not known, although it may reflect a decrease of juvenile male mortality in 1977. That, in turn, could result from the occupation of more favorable habitat consequent to the completion of impoundment construction, subsequent flooding, and stabilization of water levels.

Although our sample of fall-caught adult female reproductive tracts is small ($n = 7$), the mean number of placental scars ($\bar{x} = 17$) suggests several had three litters. Muskrats in salt marshes in Louisiana are capable of having seven or eight litters per season (O'Neil 1949, *cited by* Errington 1963). Studies in Iowa (Errington 1963) and Nebraska (Sather 1953, *cited by* Errington 1963), suggest three is the average number of litters per adult female. In Tennessee the mean litter size is 5.3 and the number of litters per female per year is 2.3 (Schacher and Pelton 1975). In Prince Edward Island, Dibblee (1970) found the mean litter size to be 7.9 from placental scar counts, 6.7 from embryo counts, and 6.6 for 33 complete litters. He concluded most females have two litters per year, some have three, and a few may have four. Dilworth (1967) examined Muskrats from the Saint John River valley and found total placental scar counts to average 15.4 per adult female, slightly less than in our sample from the Germantown Marsh.

The mean of 6.8 embryos per pregnancy in this study is higher than the mean of 5.6 reported in Manitoba (Sather 1953, *cited by* Errington 1963) and three to four in Maryland (Smith 1938; Harris 1952) but comparable to litter sizes from Nebraska (Sather 1953, *cited by* Errington 1963), Wisconsin (Beer and Trauz 1950), and Iowa (Errington 1963).

Although the first litters appeared on the Germantown Marsh in early May, the first peak in new litters occurred during the last two weeks of May, in agreement with litter production of Muskrats in the Saint John River valley (Dilworth 1967), but later than on Prince Edward Island where the major peak in litter production occurs during the second 10 d in May (Dibblee 1970). Although Dibblee (1970) found 89% of litters in Prince Edward Island were born before 15 July, we found only 75% born before that date on the Germantown Marsh in the study years. There is probably an uneven distribution of litters produced among the productive females, with those females giving birth in May probably producing three litters while later-breeding females may produce only one or two litters. The peak of immatures was captured in late September 1976, and in 1977.

The weights plotted for recaptured juveniles show a uniform pattern of gain from July through October with females averaging 37% less than males. In Iowa, Errington (1963) found that juveniles average 6.0 $g \cdot d^{-1}$ gain the first month and 7.6 $g \cdot d^{-1}$ over the first 2 mo. We found juvenile males averaged 7.5 $g \cdot d^{-1}$ weight gain in 0–60 d, very similar to that of the Muskrats in Iowa. Most other juveniles caught and weighed more than once were over 400 g in weight when first captured, which probably explains their high daily weight gains, especially for males (10.7 $g \cdot d^{-1}$).

Adults showed a consistent trend to gain weight throughout the summer, with males normally averaging 3–5% heavier than females. Adult males live-trapped in October were heavier than males caught prior to 31 July in both 1976 and 1977. Female weights in October were greater in 1977 but not in 1976. In fact, adult females weighed in October were lighter than those weighed prior to July in 1976.

Muskrats harvested in the fall were considerably heavier than mean weights of adults in Iowa. Errington (1963) found Muskrats in their second year averaged 1250 to 1300 g, whereas our fall-harvested adult males averaged slightly over 1475 g and females approximately 1425 g; one male weighed 1854 g. (The weights were of newly caught Muskrats, and most were wet, which would exaggerate their true live-

weight. It is not known in what condition the Iowa animals were weighed.) Winter adult female weights from Tennessee averaged 1221 g (Schacher and Pelton 1975). Adult males live-trapped in October of 1976 and 1977, however, averaged well over 1400 g, and females 1300 g, which suggests Muskrats on the study area are generally of greater body weight than those from Iowa or Tennessee.

Throughout the 2-yr study, the density of Muskrats on the Germantown Marsh was low when compared to that of other regions of North America. Errington (1963) estimated 4–6 Muskrats per hectare of marsh during cyclic highs in Iowa, although in years of low densities the marshes were virtually unpopulated.

Within water-covered marshes and impoundments on our study area, fall Muskrats densities, prior to harvest, ranged from 0.2 to 0.1 per hectare. This does not include the Shepody River channel where densities were considerably higher. The annual harvest, however, has averaged 75% of the estimated fall population. We can only conclude that the study population is at a periodic low and with the recent stability and improvement of habitat, population increases should be evident over the next several years. Dispersion into recently improved habitat should decrease the proportion of the population harvested and decrease juvenile and adult mortality. Both factors should contribute to population increases.

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Moose Population Dynamics and Winter Habitat Use at Rochester, Alberta, 1965–1979

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Moose (*Alces alces*) were counted from a helicopter during the winters of 1965–66 to 1978–79 on a 179-km² study area near Rochester, Alberta. Sixty-five percent of marked Moose present on the study area during 1975–1977 were observed. Estimated densities increased from 0.016/km² of nonagricultural land in 1965–66 to 0.75 in 1978–79. The mean calf-cow ratio of 106/100, and the 41% twins among calf-cow groups in winter, indicated high fecundity and calf survival. Such indices to productivity were related directly to temperatures, and inversely to snow depths, during the previous winter. Annual finite rates of population growth declined from 1.24 in 1965–66 to 1.03 in 1978–79, partly as a result of attainment of a stable age distribution, and partly as a result of an apparent shift from net ingress to net egress. Moose selected treed muskegs and upland aspen (*Populus tremuloides*) stands ≤ 10 m in height, and avoided agricultural clearings, roads, and dwellings.

Key Words: Moose, *Alces alces*, population dynamics, aerial surveys, Alberta.

Range extension and subsequent population increase of Moose (*Alces alces*) has been documented on Isle Royale (Hickie 1936), in Newfoundland (Pimlott 1953), the Kenai Peninsula (Spencer and Hakala 1964), and in central British Columbia (Hatter 1950). We recently observed these same events near Rochester, Alberta.

Moose had been largely extirpated in the Rochester area prior to its closure to hunting in 1964. From winters 1965–66 through 1976–77, and again in winter 1978–79, aerial surveys were conducted on a 179-km² (69-mi²) study area. Although these surveys were initiated to monitor Coyote (*Canis latrans*) and White-tailed Deer (*Odocoileus virginianus*) populations, Moose were also recorded.

This paper analyzes 13 yr of Moose census information and documents population growth near Rochester. It also examines habitat use as observed on the surveys.

Study Area

The 179-km² survey area (Figure 1) was located about 100 km north of Edmonton. It was covered with approximately 30% Quaking Aspen (*Populus tremu-*

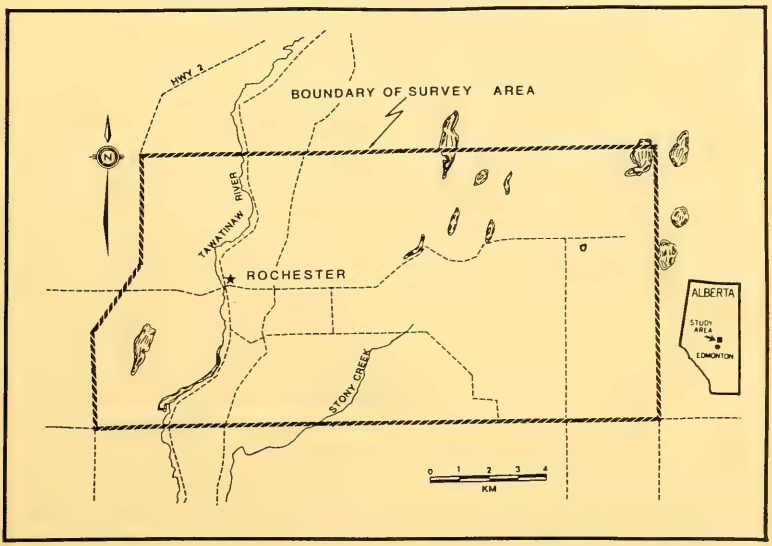

FIGURE 1. Location of the helicopter survey area at Rochester, Alberta.

loides), 10% White Spruce (*Picea glauca*) or mixed White Spruce – Quaking Aspen, 10% Black Spruce (*P. mariana*) muskeg, and 10% open bog. During the first half of this century about 35% of the study area was cleared for cultivation or pasture, mostly in the western third. Little additional clearing occurred during the course of this study. Five percent of the study area was burned in May 1968, and has since largely regenerated to aspen.

The topography is mainly flat to gently rolling with the Tawatinaw River valley and Stony Creek providing the only notable relief. The mean elevation of the study area is 685 m asl, but drops to 610 m along the Tawatinaw River.

Methods

Surveys were conducted with Bell J2 and Bell 206 helicopters flying line transects at 0.4-km intervals. Moose within 0.2 km of either side of the helicopter were counted in an attempt to obtain a total census. We usually flew three surveys per winter (range 2–6). Flight speed at an average elevation (agl) of 75 m averaged 85 km/h. Crews mostly consisted of a pilot, two observers, and an observer-recorder. Pilot interest was high and contributed to our observation efficiency.

Locations of Moose were initially plotted on maps scaled 1:63360, and later transferred to forest-cover maps scaled 1:15840. Because we felt that errors of up to 0.5 km may have been made in the original plotting of locations, a circular quadrat of 0.5-km radius centered on the initial plot was used to assess cover-type usage. Percent area of different cover types within quadrats was estimated with a dot-grid. Linear distance from Moose to ongoing human activities (occupied dwellings and roads) and habitat alterations (agricultural clearings) were also measured.

Cover-type availability on the study area was estimated from percent area within 50 random quadrats. Expected distance to human activities and habitat alterations was determined from 50 random locations.

During fall and winter, 1975–76 and 1976–77, 68 Moose were color-collared and 59 were radio-collared on the survey area or directly to the north (Mytton and Keith, unpublished data). We used these animals to calculate observation efficiencies and re-observation rates from helicopters.

Results and Discussion

Density and Distribution

Snow depths during surveys varied from 10 to 76 cm over the 13 yr. LeResche and Rausch (1974) found that observability of Moose during aerial surveys was affected by presence of snow on trees and the completeness of snow cover. To determine whether snow depth affected our observation of Moose, and therefore numbers counted, we plotted against snow depth the instantaneous rate of change ($r = \ln N_i/N_{\bar{x}}$) of each flight from that winter's mean count (Figure 2). Because the number of Moose seen was not significantly related to additional snow accumulation beyond 10 cm, no attempt was made to correct for snow-depth variation among surveys.

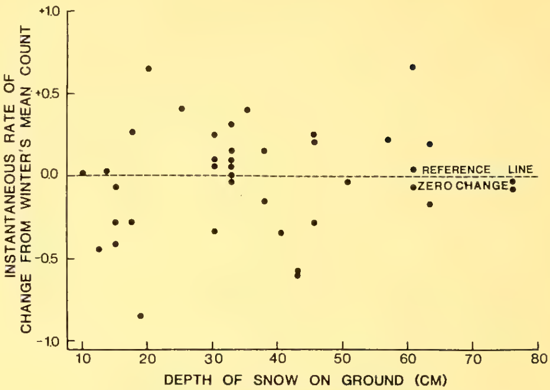

FIGURE 2. Relationship between depth of snow on ground and the instantaneous rate of change of each flight ($r = \ln N_i/N_{\bar{x}}$) from that winter's mean count ($N_{\bar{x}}$) of Moose at Rochester, Alberta, during helicopter transects.

Observation efficiencies were calculated for the four surveys in 1975–76 and 1976–77 during which the number of marked Moose on the study area was known or estimated (Table 1). Numbers of radio-collared Moose on the survey area were obtained from relocation flights immediately prior to or after surveys. We estimated numbers of color-collared Moose

TABLE 1—Efficiency of observing marked Moose at Rochester, Alberta, during helicopter transects (0.4-km intervals). Flight speed and elevation (agl) averaged 93 km/h and 70 m

	Marked moose		
Date	Number present on study area (P)	Number observed (O)	Observation efficiency (O/P)
19 January 1976	20[1]	12	0.60
	49[2]	30	0.61
20 February 1976	19[1]	14	0.74
	46[2]	30	0.66
16 December 1976	8[1]	5	0.63
1 February 1977	6[1]	4	0.67
Unweighted mean observation efficiency (± SD)			0.65 (± 0.05)

[1]Radio-marked Moose, number on area known.
[2]Color-marked Moose, number on area estimated as discussed in text.

present by assuming that they disappeared from the study area at the same rate as radio-collared Moose.

The mean of the six estimates of observation efficiency (±SD) was 0.65 (±0.05). This was similar to the mean observation efficiency of 0.68 on helicopter transects (0.4-km intervals) near Fort McMurray, Alberta (T. Hauge, personal communication). LeResche and Rausch (1974) also reported observation efficiencies of 0.61–0.70 for experienced-current observers, under good to excellent conditions, when flying either transects or concentric squares over 1-mi² pens in fixed-wing aircraft. We used a mean observation efficiency of 0.65 in calculating densities from surveys on our study area.

In 1975–76, two of three flights covered only the northern 67% of the survey area and one of two flights in 1976–77 covered just the northern 50%. We expanded these counts to the entire survey area for comparison with surveys conducted in previous years. It was first necessary, however, to correct for the uneven north-south distribution of Moose. During the winters of 1965–66 to 1974–75, 73% of the Moose were on the northern 67% of the study area, and 55% were on the northern 50%.

The mean number of Moose observed on the two to six surveys per winter was divided by the observation efficiency of 0.65 to obtain the average number of Moose present. Since 36% of the 179-km² survey area has been cleared for agriculture, the 115-km² of remaining habitat was used to calculate mean density.

Densities on the study area increased over 40-fold from a low of 0.016 Moose/km² of habitat in winter 1965–66 to 0.75 Moose/km² in 1978–79 (Figure 3). Mytton and Keith (unpublished data) reported 0.75 to 1.40 Moose/km² in winters 1975–76 and 1976–77 just north of our survey area. These densities resemble the 0.9 Moose/km², post-fire, found by Peek (1974) in Minnesota. Evans et al. (1966) estimated 1.4 Moose/km² on the Kenai Peninsula, and recent densities on Isle Royale have ranged from 1.5 to 2.7/km² (Peterson 1977). Maximum densities reported on severely overbrowsed range are 4.7/km² in Newfoundland (Bergerud and Manuel 1968) and 5.6/km² in Elk Island National Park, Alberta (McGillis 1972).

Caughley (1977, p. 25) suggested that mean group size serves as an index to population density for gregarious species. Peek et al. (1974) felt that group-size differences in three Moose populations reflected their relative densities. We found no significant relationship ($P = 0.50$) between population density at Rochester and group size (Figure 4). The large variation in group-size estimates when winter densities were below 0.2/km² was associated with smaller sample sizes. Group size remained at about 1.8 Moose/group as densities increased 4-fold from 0.20 to 0.75/km². Sim-

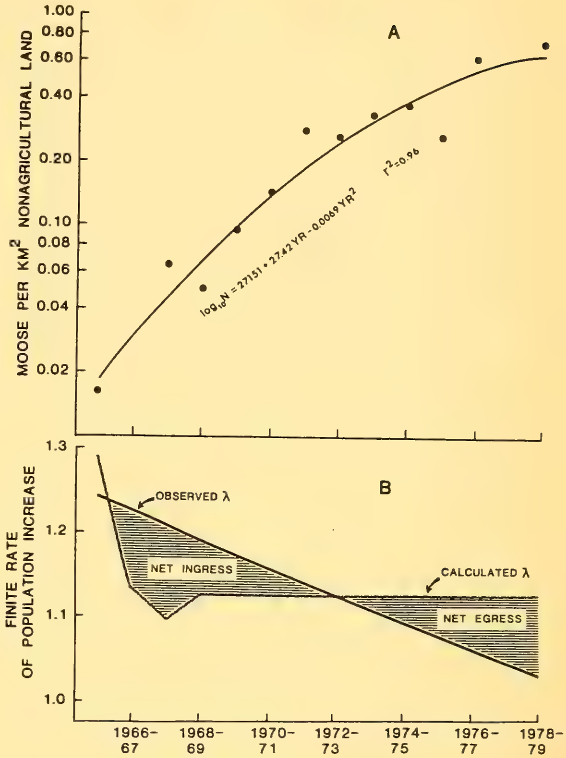

FIGURE 3. A, densities of Moose near Rochester, Alberta, during winter 1965–66 through 1978–79. Densities calculated from number counted on two to six helicopter surveys annually, and corrected for observation efficiency. YR_1 = 1965. B, observed (solid line) trend in finite rate of increase of the Moose population near Rochester, and the hypothetical finite rate of increase (slashed line) as calculated from survival and fecundity.

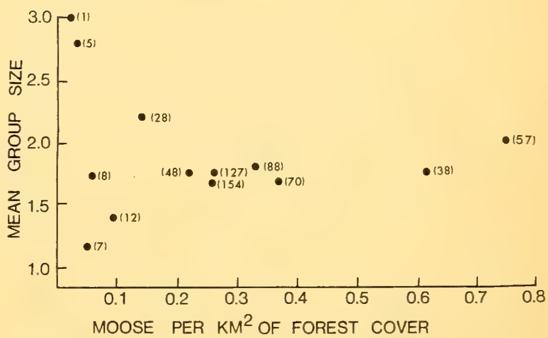

FIGURE 4. Relationship between mean size of Moose groups observed on aerial transects and winter densities during 1965–66 to 1978–79 at Rochester, Alberta. Total number of groups observed each winter shown in parentheses.

ilarly, Rounds (1978) found no change in mean size of Moose groups in Riding Mountain National Park, Manitoba, despite a reported halving of the population; and Bergerud and Manuel (1969) observed a mean (±SD) of 2.0 (±0.15) Moose/group, over densities of 1.1 to 4.6 km².

From winter 1965–66 to 1971–72 the population expanded westward, and thereafter its geographic distribution remained largely unchanged. The westernmost location in successive winters averaged 2.2 km from those of the previous year. This was intermediate to rates of spread of introduced Red Deer (*Cervus elaphus*), 1.6 km/yr, and Himalayan Thar (*Hemitragus jemlahicus*), 3.2 km/yr, in New Zealand (Caughley 1977, p. 70). Pimlott (1953) reported that Moose introduced into Newfoundland spread 8–10 km/yr, and Moose in Labrador spread about 10 km/yr (Mercer and Kitchen 1968).

Population Structure

From 1965–66 through 1974–75, antlers rather than vulva patch (Mitchell 1970) were used to determine sex. As a result many Moose on late-winter surveys were unclassified. We thus estimated population sex and age ratios from November and December surveys only (Table 2). The inverse correlation between age and date of antler drop (Hauge and Keith, unpublished data), together with the high proportion of yearlings and 2-yr-olds (61%) at Rochester (Mytton and Keith, unpublished data), would largely eliminate sexing errors during November and December.

The bull-cow ratio among yearlings and adults in November and December surveys has been consistently low (mean = 18:82). In winters 1975–76 through 1978–79 the vulva patch was used to sex Moose, and few were unclassified; the bull-cow ratio in late-winter surveys in these years averaged 19:81.

This low bull-cow ratio on our survey area probably resulted from two factors: a differentially higher egress of bulls, as discussed later; and a sex-specific difference in the distribution of Moose regionally. Mytton and Keith (unpublished data) recorded bull-cow ratios of 26:74 and 27:73 in winters 1975–76 and 1976–77 on their survey area, just north of and including the northern half of our area. They also recorded a bull-cow ratio of 47:53 (389 observations) during tagging activities in muskegs north and east of our survey area in October–December 1975.

Bull-cow ratios on the survey area have tended to increase over the years (Table 2). This was concomitant with a progressive change from net ingress to net egress, as described later, and may reflect the sex-specific nature of such movements.

The high proportion (44%) of calves observed on the survey area in November and December in part reflects the low proportion of bulls and in part the high productivity of the population. To our knowledge, this is the highest percentage of calves reported for any North American Moose population. In four regions of Alaska, calves comprised 7–32% of the population (Bishop and Rausch 1974); in Montana and Wyoming, 24–27% (Knowlton 1960; Stevens 1970; Houston 1968).

If we assume that Moose unclassified on January–March surveys were ≤1.5 yr old, the percent calves observed at that time (mean = 37%) was lower than in early winter in four of the seven years when comparable surveys were conducted in both November–December and January–March. This likely reflected the increase in mean numbers of adults on the survey area from early to late winter (Table 3). In six of these

TABLE 2—Sex and age composition of Moose observed at Rochester, Alberta, during helicopter transects in November and December

Year[1]	Number of moose observed	Number unclassified	Adult-yearling sex ratio bulls: cows	% calves
1967	9	2	0:100	33
1970	22		10:90	54
1971	26	1	13:87	38
1972	43		19:81	37
1973	49		21:79	51
1975	15		29:71	53
1976	33		15:85	39
1978	42		37:63	43
Totals and unweighted means	239	3	18:82	44

[1]Sex and age data not available for November-December 1968, 1969, and 1974.

TABLE 3—Mean number of adult[1] Moose observed per helicopter transect survey at Rochester, Alberta, during early and late winter

Year	Number of adults November-December (A)	Number of adults January-March (B)	Ratio (B/A)
1970–71	3.3	8.0	2.4
1971–72	9.0	14.3	1.6
1972–73	8.5	11.8	1.4
1973–74	12.0	17.5	1.5
1975–76	7.0	10.0[2]	>1.4
1976–77	20.0[2]	18.0	<0.9
1978–79	24.0	47.0	2.4
Mean ratio			1.7

[1]Unclassified Moose were assumed to be ≥1.5 yr old.
[2]Minimum count because surveys did not cover entire study area.

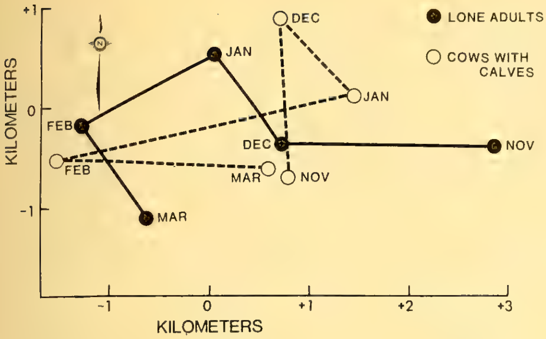

FIGURE 5. Mean monthly distribution of lone Moose and cows with calves during winters 1965–66 through 1978–79 at Rochester, Alberta. Origin was determined as the mean location of all observations.

seven years the mean number of adults on the survey area in late winter was 1.4 to 2.4 times that present in early winter. This increase in adult numbers was due to a seasonal movement from the muskegs on the east to the uplands on the west (Figure 5). Direct evidence of this shift in distribution came from tracking radio-collared Moose (Mytton and Keith, unpublished data).

Productivity

Mean calf–cow ratios (106:100) and twinning rates (41%) observed in winter at Rochester (Table 4) were the highest yet recorded, and also exceeded most reported *in utero* and during summer (Table 5). These rates indicated consistently high reproduction and early calf survival; the former was undoubtedly due to abundant browse supplies (Blood 1974; Markgren 1974), the latter was associated with an absence of Gray Wolves (*Canis lupus*) and scarcity of Black Bears (*Ursus americanus*).

There were significant yearly differences in both percent of cows with calves and in twinning rates when we tested by chi-square, but these two statistics were

TABLE 4—Percent of cows with calves, twinning rates, and calf–cow ratios of Moose at Rochester, Alberta, during winter helicopter transects. Number of cows and calf-cow groups are shown in parentheses

Winters	% cows with calves	% calf-cow groups with twin calves	Calves per 100 cows
1965–66 through 1969–70	60 (20)	58 (12)	105
1970–71	88 (25)	59 (22)	140
1971–72	59 (27)	31 (16)	78
1972–73	72 (93)	31 (67)	98
1973–74	70 (50)	46 (35)	106
1974–75	100 (24)	46 (24)	146
1975–76	90 (64)	38 (58)	100
1976–77	53 (32)	41 (17)	88
1978–79	70 (46)	17 (32)	89
Unweighted means (± SD)	74 (± 16)	41 (± 13)	106 (± 23)

TABLE 5—Comparison of calf-cow ratios and twinning rates of North American Moose populations

Region	Time of year	Calves per 100 cows (mean range)	Twinning rate (%)[1] (mean range)	Reference
Alberta, Rochester	Winter	106 (78–146)	41 (17–59)	This study
Wyoming	Winter	59 (49–66)	5	Houston (1968)
Montana	Winter	54 (52–55)	3	Stevens (1970)
Alaska	Winter	38 (21–60)	14 (10–18)	Spencer and Chatelain (1953)
Alaska	Winter	37 (18–90)		Bishop and Rausch (1974)
Newfoundland	Fall and winter	37 (33–41)	12 (10–13)	Pimlott (1959)
Alaska	Fall	17 (7–38)	8 (0–19)	Faro and Franzmann (1978)
Isle Royale	Fall	17 (9–22)	10	Peterson (1977)
Alberta, Fort McMurray	Spring	82 (64–100)	33 (29–36)	Hauge and Keith (unpublished data)
Montana	Summer	59 (53–69)	3 (0–8)	Peek (1962)
Ontario	2	113 (17–142)	25 (8–50)	Simkin (1965)
Alberta, Elk Island	2	89 (73–123)	13 (4–48)	Blood (1974)
British Columbia	2	60 (20–83)	10 (0–32)	Edwards and Ritcey (1958)

[1]Percent of calf-cow groups with twin calves.
[2]*In utero.*

not linearly related ($P = 0.42$). Between-year differences in percent calves in the population were not significant owing to small sample sizes (Table 2), but percent calves in the population was significantly linearly related to percent of cows with calves.

There was no relationship between population density and percent cows with calves, twinning rates, or percent calves in the population.

We explored through linear regression whether over-winter temperatures and snow conditions might affect productivity of Moose at Rochester, as reflected the following winter by percent calves, twinning rates, and percent cows with calves. Because we had no precise information on what constitutes "stressful" winter weather, we determined the number of days each winter (October–April) when mean temperatures fell below −7, −12, −18, −23, and −29°C (20, 10, 0, −10, −20°F) and snow depths exceeded 13, 25, 38, 51, and 64 cm (5, 10, 15, 20, 25 in). These numbers were then used as independent variables in our analysis.

Overall, decreasing percentages of calves and twins were associated with increasing number of days with temperatures below, and snow depths above, our arbitrarily chosen values. Twinning rates were significantly negatively related to number of days below −18°C ($r^2 = 0.70$, Figure 6). The negative relationships between percent calves and number of days below −7 and −12°C were both statistically significant ($r^2 = 0.57$ and 0.68, Figure 7), as was the negative relationship between percent calves and number of days when snow depths exceeded 25 cm ($r^2 = 0.51$). A multiple regression combining number of days below −12°C and number with snow depths exceeding 25 cm ac-

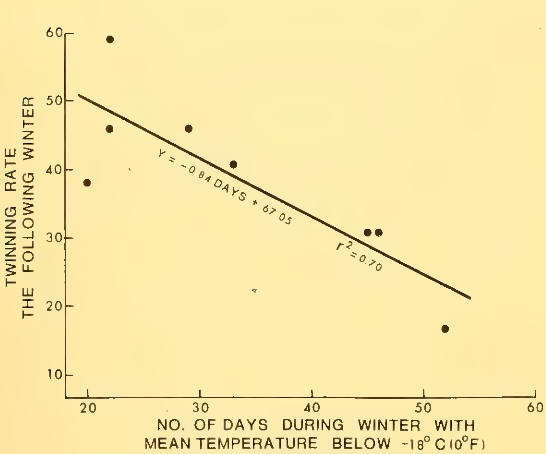

FIGURE 6. Relationship between number of days each winter with mean temperature below −18°C (0°F) at Rochester, Alberta, and percent of calf–cow groups with twin calves the following winter.

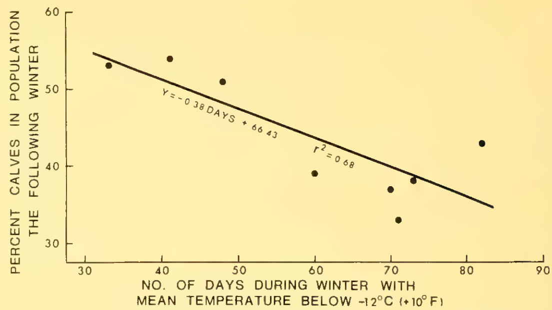

FIGURE 7. Relationship between number of days each winter with mean temperature below −12°C (10°F) at Rochester, Alberta, and percent calves in the population the following winter.

counted for 76% of the variation in percent calves in the population.

$$Y_i = 69.46 - 0.29A_i - 0.10B_i$$

$$r^2 = 0.76;\ P < 0.05$$

where Y_i = percent calves in the population;
A_i = number of days with mean temperature <−12°C;
B_i = number of days when snow depths exceeded 25 cm.

We detected no relationship between percent cows with calves and our weather variables; nor between any of the above three productivity indices and total annual snowfall or date when snow depth decreased to less than 5 cm.

The foregoing regression analyses strongly suggested that duration of winter cold and deep snows affected subsequent productivity of Moose. We cannot say whether the effect was direct (increasing energy demands of the cow) or indirect (through changes in plant phenology as suggested by Stewart et al. (1977)) nor whether the attendant losses of calves were primarily *in utero* or *post partum*. We would emphasize, however, that at Rochester these demographic responses occurred at higher temperatures and shallower snow depths than previously considered "stressful." Gasaway and Coady (1974), for example, felt that metabolic rates of Moose did not increase until ambient temperatures fell below −40°C, and Coady (1974) concluded that snow depths less than 40 cm were of little or no hindrance to movement.

Rates of Increase

The observed finite rate of increase (λ) of the Rochester Moose population was derived by differentiating the population growth curve (Figure 3). The annual rate declined 17% from 1.24 to 1.03 as the population rose from 0.016 to 0.75/km². We also calculated a hypothetical rate of increase (Caughley 1977, p. 110) using age-specific rates of survival and

TABLE 6—Re-observation rates of color-collared Moose at Rochester, Alberta, during six helicopter transect surveys (0.4-km intervals) and two fixed-wing transect surveys (0.8-km intervals) in winters of 1975–1976 and 1976–77. Total number of collared individuals in each cohort is shown in parentheses. Means which are not significantly different ($P > 0.05$) using square-root transformed data and t-tests are underlined

	Number of individuals in each frequency class					
Frequency of re-observation	Adult cows (20)	Male calves (8)	Yearling cows (7)	Female calves (13)	Adult bulls (11)	Yearling bulls (9)
0	1	1	1	5	3	8
1	3	2	2	1	3	
2	7	3	3	5	5	
3	6	2	1	2		1
4	2					
5	1					
Mean number of re-observations	2.40	1.75	1.54	1.31	1.18	0.33

fecundity observed at Rochester during 1975–1978 (Mytton and Keith, unpublished data) and starting with a population of adult cows (Figure 3). This latter assumption was consistent with our field observations during the first 2 yr of the study, i.e., all cows had twins and were thus ≥3.5 yr old (Markgren 1974; Blood 1974).

The initial sharp decline in the hypothetical λ, from 1.29 to 1.12, was due to a rapid buildup of yearlings and 2-yr-olds as the population approached a stable age distribution. This same phenomenon likely also accounted in part for the decline in λ observed in the actual population.

The Rochester population was originally in a period of net ingress. Once the age structure stabilized, the observed λ was 6% greater than that predicted from fecundity and survival alone. As densities rose, the observed λ declined until in 1978–79 it was 8% lower than that predicted from fecundity and survival. Because adult survival was known to be high (0.84 annually) as late as 1975–1978 (Mytton and Keith, unpublished data), and recruitment, as indexed

TABLE 7—Percent area of vegetation types within circular quadrats (0.8 km²) centered on locations of Moose[1] at Rochester, Alberta, during winter helicopter transects[2]

Vegetation type	November	December	January	February	March	% available[3]
Tall aspen (>10 m)	12	12	13	14	14	16
Short aspen	24	16	22	20	26	14
Coniferous	0	0	0	1	0	1
Aspen-conifer mix	2	3	4	8	7	6
Burn	4	6	5	3	1	5
Total upland	42	37	44	46	48	42
Treed muskeg	25	25	19	16	17	12
Willow	17	15	14	11	11	11
Open muskeg	3	4	2	2	1	1
Total lowland	45	44	35	29	29	24
Agricultural clearings	12	18	18	23	21	34
Lakes and ponds	1	1	3	2	2	0
Total number of observations	23	95	96	129	100	

[1]Cow-calf groups and adult groups were treated as single samples.
[2]Distributions of vegetation use were significantly different than availability (chi-square tests, $P<0.05$) in all months except November, which had the smallest sample size.
[3]Cover-type availability calculated for entire helicopter survey area from 50 randomly placed quadrats.

by calf–cow ratios in winter, did not decline significantly during 1965–1979 (Table 4, Column 4), the drop in observed λ probably indicates a shift from the period of net ingress to one of net egress.

Two observations in the later years of the study suggest that egressing individuals were primarily yearlings. Mytton and Keith (unpublished data) reported that three radio-collared cows and one bull dispersed permanently from the Rochester Study Area; all were ≤2.5 yr old when they left. In 1975–1977, bulls color-collared as yearlings were re-observed significantly less often than adult cows, calves, yearling cows, or adult bulls (Table 6). Adult cows were re-observed more frequently than female calves, or adult and yearling bulls. Three factors could affect sex- and age-specific re-observation rates: (1) differential survival, (2) differential observability, and (3) differential movement. Because Mytton and Keith (unpublished data) found no difference in survival of radio-collared yearlings and adults, or in observability of radio-collared bulls and cows, differential movement was evidently responsible for the very low re-observation rate of yearling bulls.

Habitat Use

Our index to habitat use was provided by percent area of different vegetation types within 0.5 km of Moose locations (Table 7). Mytton and Keith (unpublished data) and Hauge and Keith (unpublished data), using radiotelemetry at Rochester and Fort McMurray, Alberta, noted greater use of open lowlands by bulls vs. cows in late fall and early winter. We detected no such difference in habitat use, but the number of bulls observed was small.

We compared (chi-square tests) habitat use and availability (Table 7) to assess preference. In general, Moose tended to avoid agricultural clearings and to select treed muskeg and immature aspen stands (≤ 10 m tall). Use of lowland vegetation types decreased notably from early to late winter, as Moose moved onto the more densely forested uplands. This same shift has been observed elsewhere in North America (Hauge and Keith, unpublished data; Peek et al. 1976; Houston 1968; Chamberlin 1972; Telfer

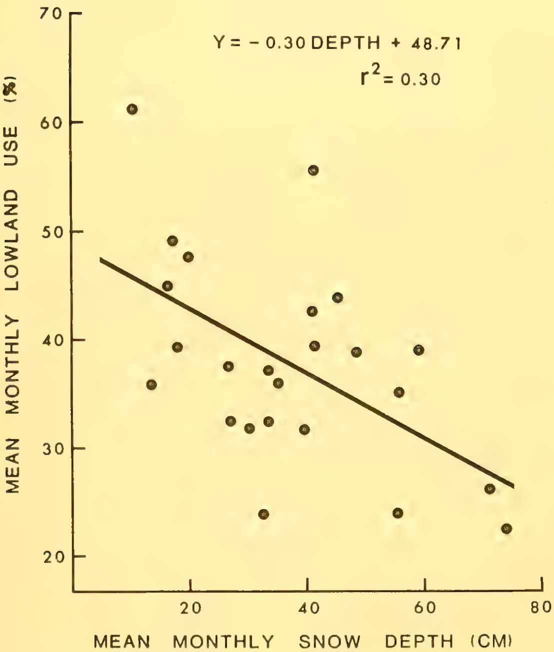

FIGURE 8. Relationship between mean monthly snow depth and use of lowlands by Moose at Rochester, Alberta, during helicopter transects.

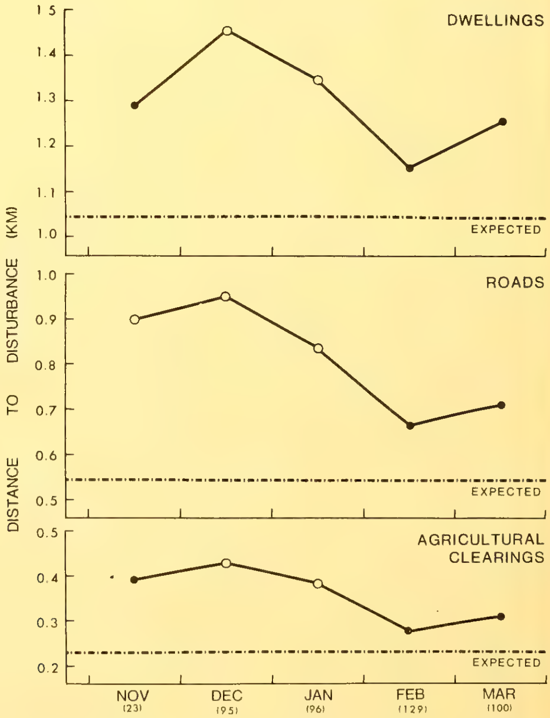

FIGURE 9. Mean distance from human disturbance to Moose sightings during winter helicopter transects at Rochester, Alberta. Dashed lines represent mean distance from disturbance to 50 random locations. Open circles indicate months when mean distance to disturbance was significantly different (P>0.05) from expected, using t-tests. Number of Moose groups observed each month in parentheses.

1970), and is probably triggered by greater snow accumulation in open areas. In winter 1975–76, for example, snow depths in lowland and open upland sites at Rochester were 70% deeper than on closed-canopy uplands. Lowland use was significantly negatively related to mean monthly snow depths (Figure 8). Knowlton (1960) and Van Ballenberghe and Peek (1971) noted that Moose frequented denser cover during periods of rapid snow accumulation. It is also possible that closed-canopy uplands offer Moose a more favorable thermal environment with less temperature variation.

Coincident with movement onto uplands during January–March, was an increased percentage of agricultural clearing within 0.5 km of Moose locations (Table 7) and a decreased mean distance to dwellings, roads, and clearings (Figure 9). These changes were a consequence of such disturbances being largely associated with upland sites. Moose were consistently further from disturbances than were random locations, but only significantly so during December and January. In a second analysis we assumed that agricultural clearings were non-habitat, and compared distances of Moose from disturbance with distances of 50 random locations within Moose habitat. Once again, Moose were significantly further from roads and dwellings in December than would be expected by chance; but in no month (November–March) were Moose significantly further from agricultural clearings than were random locations within Moose habitat.

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Variation in Distribution and Abundance of Four Sympatric Species of Snakes at Amherstburg, Ontario

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Mapping of the local distribution and abundance of four sympatric species of snakes in a 40-ha study area near Amherstburg, Ontario, revealed four strikingly different patterns. No seasonal variations in these distribution patterns were observed. The most widespread and abundant species in the study area was Butler's Garter Snake (*Thamnophis butleri*), which had a large portion of its population in a seasonally dry upland area. The restricted distribution of the Eastern Garter Snake (*Thamnophis s. sirtalis*) corresponded well with the distribution of standing water and amphibian prey. The Brown Snake (*Storeria dekayi*) occurred primarily in moist areas of dense vegetation where slugs were common, but extended further into the dry upland than *T. s. sirtalis*. The Fox Snake (*Elaphe vulpina gloydi*) was widespread but uncommon in both dry and moist portions of the study area. The existing literature has associated *T. butleri* and *E. vulpina gloydi* more often with moist situations. Competition with both *T. s. sirtalis* and *S. dekayi* may explain the scarcity of *T. butleri* in a relatively moist area where all three occurred together. The absence or rarity of *T. s. sirtalis* and *S. dekayi* in the dry upland where *T. butleri* was abundant may result from an inability of the former two species to withstand drought and/or a competitive advantage of *T. butleri* in this seasonally dry habitat. The suite of characteristics which adapt *T. butleri* to earthworm prey are also functionally useful in drought avoidance.

Key Words: *Thamnophis butleri, Thamnophis sirtalis sirtalis, Storeria dekayi, Elaphe vulpina gloydi,* sympatry, ecology, distribution, habitat, competition, drought, southwestern Ontario.

During the summers of 1976 and 1977 we studied four species of snakes co-existing in a 40-ha area 2.4 km NE of Amherstburg (42°07′N, 83°05′W) in Essex County, Ontario (Catling and Freedman 1977, 1979; Freedman and Catling 1978, 1979). A large part of our field work at Amherstburg was directed toward collecting data on local distribution and abundance; there are few previous studies done on a local basis. Such information provides the basis for an understanding of the various factors affecting local sympatry in closely related and/or similar species.

This report documents the patterns of local distribution and abundance of the Eastern Garter Snake (*Thamnophis s. sirtalis*), the Butler's Garter Snake (*Thamnophis butleri*), the Brown Snake (*Storeria dekayi*), and the Fox Snake (*Elaphe vulpina gloydi*). It also considers some of the ways in which these patterns may relate to sympatry through the effects of prey availability, competitive interaction, and adaptation to seasonal drought.

Study Area

The dominant features of the study area are illustrated in Figure 1. Most of the western portion is comprised of an old limestone quarry and waste beds belonging to Allied Chemical Ltd. It is relatively high and rocky, and has irregular topography in contrast to the lower and flat eastern portion. The quarry, which has been abandoned for at least 15 yr, is bounded on the west by a frequently-used north-south gravel road, 10 m wide, and on all other sides by a narrower and little-used gravel road 4–5 m across. Some smaller areas to the west of the quarry have been abandoned for several years but much of this peripheral area has been disturbed by bulldozing, dumping, quarrying, and other activities.

Essentially flat and lower in elevation, the eastern portion of the study area is mainly comprised of abandoned industrial and agricultural lands, last occupied for these purposes more than 5 yr previous to our study. Several derelict buildings, as well as piles of scrap and rubble remaining from a previous smelter facility, are situated in the west-central section of the study area. The wooded valley of Big Creek cuts across the far eastern portion. There are a few areas of recently cultivated (within the last few years) ground, and presently cultivated fields of corn exist along the southern boundary.

Although vegetation and substrate are very patchy and variable over distances of only a few metres, it is readily observed that there are three major biophysiographic regions in the study area (Figure 1). In addition to these, there are minor areas of disturbed barren ground, scrub, cultivated, and recently cultivated

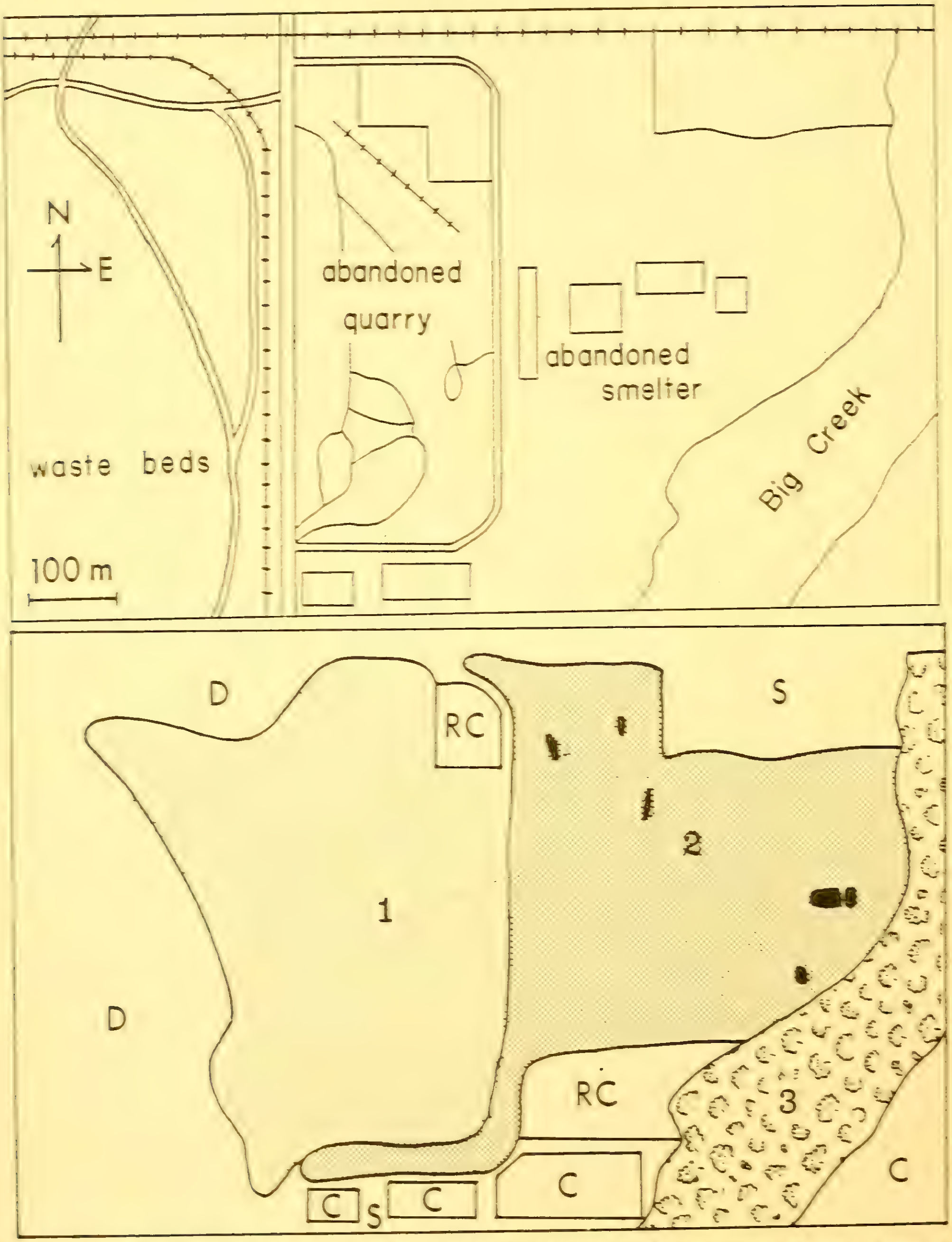

FIGURE 1. Maps of the study area showing general surface features (upper) and biophysiographic zones (lower). 1 = dry, well-drained upland with relatively low vegetation cover values; Cottonwood and Hawthorn clumps with much dry grassland and rocky ground with sparse vegetation cover, limestone bedrock at the surface, ephemeral pools in the spring only. 2 = low flat area with rank cover of grasses and forbs, in many places permanently moist, with ditches and wetlands having *Typha* spp. and permanent pools scattered throughout. 3 = Oak-Hickory woodland on slopes of Big Creek valley. D = disturbed ground (bulldozed within last 2 yr); RC = recently cultivated; C = presently cultivated; S = scrub.

ground. Area 1 (Figures 1 and 2) consists of the rocky, topographically irregular quarry area representing the highest elevations on the site (ca. 225 m). This area may be wet in spring and fall with small temporary pools, but it dries out by June, and is very dry with no standing water in July and August. Deeper soils in localized areas are composed of fine clay (pH 7.6–7.8) that hardens upon drying and cracks into deep fissures. In most places the soil is shallow, and rocky substrate ranging from outcroppings of bedrock to piles of boulders or smaller stones is frequent. The area is essentially sparse open grassland. Much of it has been used as an unmanaged garbage dump and numerous fires started to burn trash have helped to maintain the open grassland.

Area 2 is lower in elevation (ca. 183 m) and essentially flat, without rock in the form of either outcropping or piles. The vegetation is generally a dense cover of grasses and forbs, but drier areas of sparse vegetation, not unlike that characteristic of Area 1, occur in a few places. Throughout there are pockets of soil that remain moist during the summer, as well as six permanent pools (Figure 3). In addition, the numerous ephermeral pools in this area last much longer than those in Area 1, still having water in late June or early July.

Area 3 consists of the wooded (Oak-Hickory) valley and banks of Big Creek (elevation 180 m).

Methods

During spring and summer of 1976 and 1977, 10 visits were made to the study area. These were, in 1976: 14 May, 30 May, 15 June, 10 July, and 24 July.

FIGURE 2. Dry rocky upland with scattered Cottonwoods (*Populus deltoides*), Sumacs (*Rhus typhina*, *R. glabra*), and Dogwood (*Cornus drummondii*). The sparse open grassland is dominated by *Poa compressa*, *Poa pratensis*, *Bromus japonica*, *Sporobolus neglectus*, *Diplotaxis tenuifolia*, *Daucus carota*, *Pastinaca sativa*, *Vitis riparia*, and *Parthenocissus vitacea*.

FIGURE 3. Permanent pond surrounded by Cattail (*Typha* spp.) with Bur Oak (*Quercus macrocarpa*) to the right, in Area 2. The plant community in the foreground and behind the pool is dominated by *Melilotus alba, Daucus carota, Poa pratensis, Agropyron repens, Phleum pratense,* and *Dactylis glomerata.*

and in 1977: 11 April, 6 May, 26 May, 15 June, and 20 July. On each of these visits the 40-ha study area was systematically searched for snakes over a 1- or 2-d period. Searching included wandering through vegetation, and turning over rocks and debris. The study area was divided into 50-m squares on aerial photographs, and the numbers of snakes of each species found in each square on each visit was recorded.

The distributions of various prey species observed in the study area during these searches were also mapped, as were the general surface features and vegetation, so that these patterns could be compared with the local distribution and abundance of snakes.

Results and Discussion

Distribution and Abundance of Snakes

Figures 4 and 5 indicate that each of the four species of snakes had different patterns of local distribution and abundance. *Thamnophis butleri* was the most common and widespread snake in the study area. Pockets of abundance appeared in the center of Area 1 and along the western extension of Area 2. Unlike the other three snake species, *T. butleri* was abundant in Area 1, and in fact was most abundant in this dry upland area. It was exceeded in abundance by both *T. s. sirtalis* and *S. dekayi* in the eastern portion of Area 2. There was relatively little overlap between *T. butleri* and the congeneric *T. s. sirtalis* in our study area.

Thamnophis butleri is generally associated with moist habitat (Ruthven 1908; Schmidt and Davis 1941; Carpenter 1952; Wright and Wright 1957). Prior to this study the only reference to *T. butleri* inhabiting dry areas was that of Logier (1939).

In contrast to *T. butleri, S. dekayi* and *T. s. sirtalis* were more or less restricted to the lower and more moist Area 2, where pockets of abundance occurred. Interestingly, *S. dekayi* and *T. butleri* both occupied

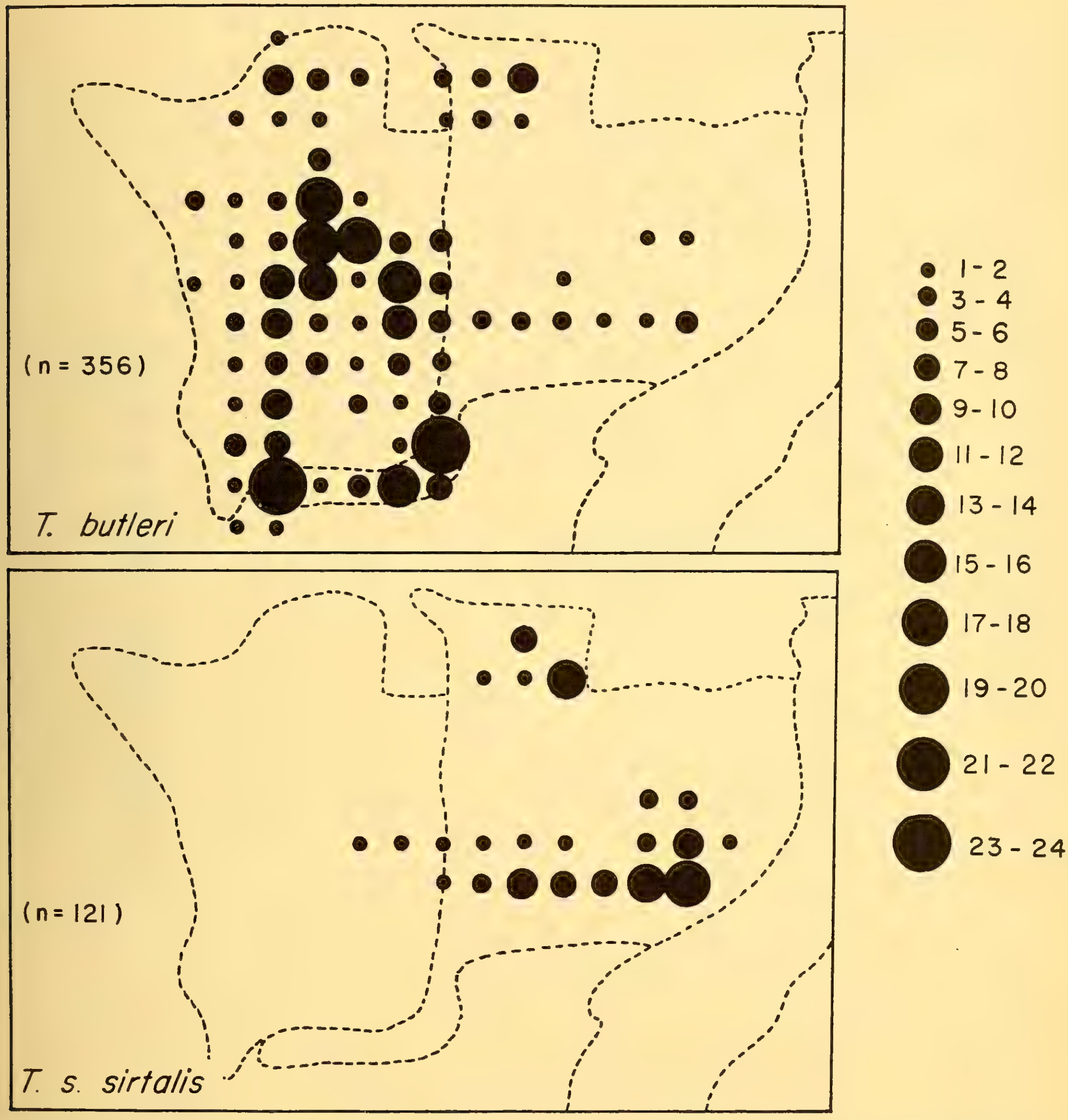

FIGURE 4. Distribution and abundance of *Thamnophis butleri* and *Thamnophis s. sirtalis* in the study area. Data are a summary of 10 visits in 1976 and 1977. n = total number of snakes. The relationship between spot size and total number of snakes captured in a 50 x 50 m quadrat is illustrated to the right.

moist ditches comprising the southwestern extension of Area 2, but *T. s. sirtalis* was never found here. *Storeria dekayi* occupied the entire area of distribution of *T. s. sirtalis,* and a part of the area of distribution of *T. butleri,* but was less common than either of these in the area of overlap. *Storeria dekayi* is generally reported in the literature to occupy a great variety of habitats (Wright and Wright 1957).

Carpenter (1952) found *T. s. sirtalis* in his study area to be widespread in a variety of habitats, and he compared this to the relatively restricted distributions of *T. butleri* and the Eastern Ribbon Snake (*T. s. sauritus*). In general, the literature reports *T. s. sirtalis* from a wide variety of habitats, but associates the snake with wet places; "It prefers to be near water, but also wanders far from it into high and dry places" (Logier 1958). Wright and Wright (1957), in a review of numerous references to its habitat, suggested that

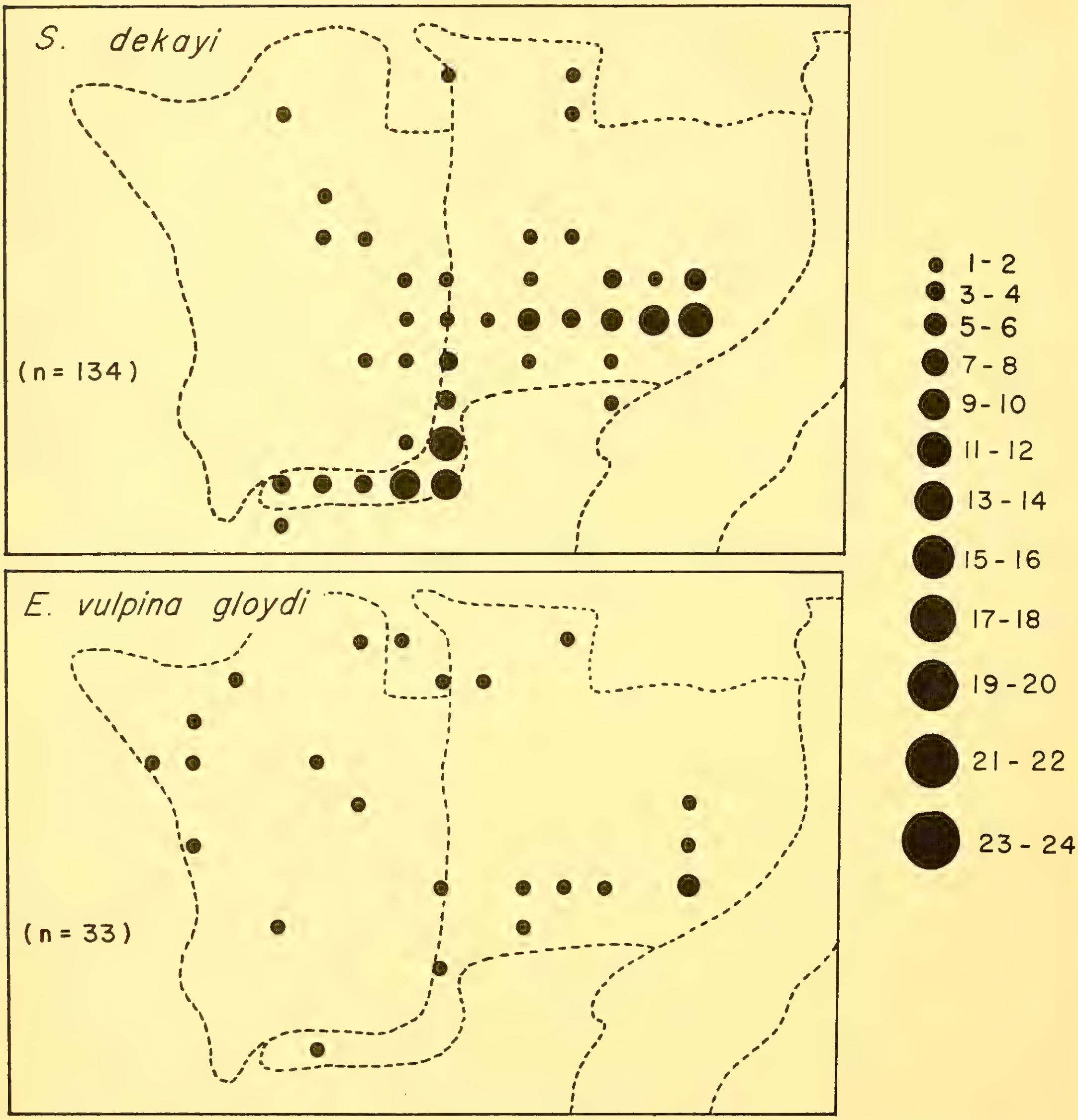

FIGURE 5. Distribution and abundance of *Storeria dekayi* and *Elaphe vulpina gloydi* in the study area. Data are a summary of 10 visits in 1976 and 1977. n = total number of snakes. The relationship between spot size and total number of snakes captured in a 50 x 50 m quadrat is illustrated to the right.

T. s. sirtalis is semi-aquatic. Considering these references (see also Fitch 1965), it is not surprising that we found it confined to the relatively moist Area 2, where there were several permanent pools of water.

Elaphe vulpina gloydi was widespread but relatively uncommon in both Areas 1 and 2 with no obvious pockets of concentration (Figure 5). Conant (1938) and Logier (1958) suggested that this constrictor occurs in and near extensive lakeside marshes. Rivard (1976) found it in a variety of open habitats, but frequently within 10 m of a marsh shoreline. Interestingly, several *E. vulpina gloydi* were found in Area 1 in midsummer, at least 500 m from the nearest standing water.

Seasonal Variation in Distribution

Thamnophis butleri was found to be somewhat more concentrated in local areas in spring, and less concentrated in the summer. The concentrations of snakes in some areas may have resulted from spring emergence of a large group simultaneously from nearby hibernacula, or they may represent sexual aggregations, for example a large number of males attracted by a few females. Sexual aggregations of *T. butleri* are reported by Finneran (1949). But observations in both spring and summer were widespread throughout the study area, and overall distribution did not differ much. Similarly, the other three species did not demonstrate any differences in distribution at different seasons. Seasonal changes in distribution were not expected on the basis of the relatively short movements of marked snakes, most of which travelled less than 50 m (Freedman and Catling 1979).

Factors Affecting Distribution

Jordan (1967) thought that vegetation cover or factors limiting vegetation cover determined the distributions of the Plains Garter Snake (*Thamnophis radix*) and *T. s. sirtalis* in a praire-forest ecotone in Minnesota. Both Areas 1 and 2 of our study area are essentially open and grassy, but very variable in the amount and composition of vegetative cover (as described above). No direct relationship between the presence of a particular species of snake and a particular vegetative cover was apparent. For instance, *T. s. sirtalis* was frequently found in Area 2 in sparse vegetation of the type characteristic of large portions of Area 1. Distinctive patterns of distribution and abundance of snakes in our study area appear to be related to some combination of factors associated with the general features of the landscape. These factors include (1) different patterns of prey availability accompanied by differences among the species of snakes using the various prey species, (2) competitive interactions between species of snakes in certain habitats, and (3) differences between snake species in adaptation to different microenvironments, particularly differences in ability to withstand drought. These factors will be considered separately.

1) *Distribution of prey*

The basis for differences between the snake species in prey usage has been considered (Catling and Freedman 1979). Here we will focus upon prey distribution as it relates both to food actually taken, and to local distribution and abundance of the different snake species.

Both the literature and our data from Amherstburg (Catling and Freedman 1979) suggest that *S. dekayi* feeds largely on slugs and earthworms. The distribution of this snake in our study area corresponds well with the areas of abundance of the former prey.

The pattern of distribution and abundance of *T. s. sirtalis* corresponds closely with the distribution of Leopard Frogs (*Rana p. pipiens*) and American Toads (*Bufo a. americanus*) in our study area. Amphibians are reported to comprise a significant portion of the prey of *T. s. sirtalis*, and they did so in our study area (Catling and Freedman 1979).

Elaphe vulpina gloydi is reported to feed chiefly on mammals, birds, and birds' eggs (Conant 1938; Logier 1958; Rivard 1976). The widespread occurrence of Meadow Voles (*Microtus pennsylvanicus*) in our study area corresponds well with the distribution of *E. vulpina gloydi*.

Thamnophis butleri, T. s. sirtalis, and *S. dekayi* all prey upon earthworms, but these seem to be most important in terms of total diet to *T. butleri* (Catling and Freedman 1979). The species of earthworm eaten by *T. butleri* appear not to account for the unusually large population of this snake in our study area (Freedman and Catling 1978; Catling and Freedman 1979). All of these earthworms are more or less widespread in Ontario (Reynolds 1977). It is quite possible that the variety of earthworm species present, and the abundance of debris at the study site makes this prey more available than is usually the case. Beneath such widespread debris as rocks, decaying wood, mattresses and furniture, tins, rubber, and tar paper, and within dumped garden refuse and decomposing paper and cardboard, worms are available that otherwise do not come to the surface. Although it seems reasonable to explain the large population of *T. butleri* in the study area partially on the basis of prey and prey availability, the pattern of distribution and local abundance of this snake is not so easily explained.

No marked differences in abundance of earthworms were noted in Areas 1 and 2 in late April and early May. As the spring progressed much of Area 1 began to dry out, and by midsummer earthworms were rarely seen there. Earthworms could, however, be found under piles of trash and in moist ditches in many parts of Area 2 until late summer, when some of these areas also began to dry out. Thus, availability of earthworms to snakes appeared to last much longer into the summer drought in Area 2 than in Area 1. Although none of the snakes in our study area were directly associated with overall earthworm distribution, *T. s. sirtalis,* and to a lesser extent *S. dekayi,* were associated with areas of more continuous earthworm availability, while *T. butleri* was associated with an area of relatively ephemeral earthworm availability.

Thus, the distribution and abundance of the "preferred prey combination" (i.e., prey taken most frequently under natural circumstances) is correlated with the distribution of three of the four species of

snakes. But the complete exclusion of *T. s. sirtalis* and partial exclusion of *S. dekayi* from Area 1 is not explained by the absence of prey *per se,* because earthworms are seasonally present here and both of these snakes are capable of utilizing earthworms as a significant portion of their diets (Catling and Freedman 1979). The distribution and abundance of *T. butleri* is apparently not explained by the distribution and abundance of prey. This snake was relatively scarce in Area 2, where earthworms are abundant and available for a relatively long period.

2) *Competitive interactions*

Various authors have presented evidence that *T. butleri* is better adapted to feeding on earthworms than *T. s. sirtalis* (see Catling and Freedman 1979). Relatively small size, activity periods corresponding to earthworm activity, and physiological and behavioral adaptations of *T. butleri* may all contribute to its better adaptation to earthworm prey. R. J. Planck and J. T. Planck (1977, unpublished report to the Department of Supplies and Services) speculated that *T. butleri* displaces the ecologically more general *T. s. sirtalis* (see also Fitch 1965, p. 506) to areas of less competition and to prey species for which competition is decreased. They reported areas where *T. butleri* was more abundant than *T. s. sirtalis,* but they did not find any areas where *T. butleri* occurred to the total exclusion of *T. s. sirtalis.* This latter situation is very obvious in parts of our study area (Figure 4), and may be partly owing to a competitive advantage of *T. butleri* in the dry upland where only earthworm prey is available. On the other hand, *S. dekayi* and *T. s. sirtalis* might have a competitive advantage in Area 2 where prey in addition to earthworms is available, and where earthworm availability is prolonged, thereby partially displacing *T. butleri.*

3) *Ability to withstand drought*

Thamnophis butleri, which had a large portion of its population permanently centered in the dry upland of Area 1, and *S. dekayi,* which was also present there in low numbers, must have been able to withstand the severe midsummer drought that occurred there. *Elaphe vulpina gloydi* also had a large portion of its population in this area. Desiccation might be avoided by aggregation and aestivation during hot, dry weather, by nocturnal activity, or it may be tolerated.

Both *T. butleri* and *S. dekayi* are found in aggregations at times of the year other than early spring and late fall (Noble and Clausen 1936; Finneran 1949). Apparently snakes can follow trails left by the skin of conspecifics (Noble and Clausen 1936). This could lead to aggregations and might assist newcomers in an area to find appropriate cover. Aggregation may be facilitated in snakes that are scent-oriented with respect to prey, and it would be a distinct advantage in a seasonally-dry habitat because water loss through the skin and through ventilation is decreased in members of an aggregated group (Noble and Clausen 1936). Summer aggregation and aestivation would not only help them to avoid drought, but would also result in activity periods corresponding to those of earthworm prey.

The relative scarcity of *T. butleri* in our study area in June and July did not appear to be the result of emigration (Freedman and Catling 1979). Rather it appeared that *T. butleri* or a large proportion of its population was hiding.

Continued activity of *T. butleri* in permanently moist sites during the summer may help to explain the frequent association of *T. butleri* with wet sites, reported in most of the literature (e.g., Carpenter 1952). Although this snake may be readily apparent in moist situations, it could still be very abundant yet inconspicuous in sites that are dry in midsummer. Its presence in an extensive dry upland area indicates that *T. butleri* does not necessarily require areas of continuous earthworm activity, contrary to the suggestion of Planck and Planck (*op. cit.*). In fact it may have an advantage over other species (e.g., *T. s. sirtalis* and *S. dekayi*) in summer-dry situations.

Evidence for nocturnal activity of *T. butleri* and *S. dekayi* has been presented previously (Catling and Freedman 1979). All of the 33 *E. vulpina gloydi* seen during our study were found under cover, suggesting that this snake also may avoid drought by nocturnal activity. No information on relative drought tolerance is available for the snake species discussed here.

Both *T. butleri* and *E. vulpina gloydi* are biogeographically associated with the summer-dry prairie environment and are presumably adapted to coping with drought stress. *Thamnophis butleri* is endemic to the prairie peninsula region. It may have emigrated from the west with the extension of the grasslands into the eastern peninsula region 8000 to 4000 years ago, later persisting in isolated pockets during the reinvasion of forests (Transeau 1935; Schmidt 1938; Sears 1942; Smith 1957; Wright 1968). *Elaphe vulpina gloydi* is also thought to have extended its range eastward through the post-Wisconsin prairie peninsula region, with the later reinvasion of forests isolating the eastern and western populations (Schmidt 1938; Conant 1940; Smith 1957; Bleakney 1958). Considering the affinities of *T. butleri* and *E. vulpina gloydi* to the western summer-dry regions, it does not come as a surprise that these species should be able to withstand the extreme midsummer dryness of Area 1.

Interestingly, Kirtland's Water Snake (*Natrix kirtlandii*), which has a prairie peninsula distribution similar to that of *T. butleri*, occupies relatively small open

grassy areas that have ephemeral pools in spring and become dry in midsummer, at which time the snakes are very scarce and are known to aggregate (Conant 1943). Conant noted that *N. kirtlandii* feeds chiefly on earthworms and that its periods of apparent abundance were associated with periods of rain. We postulate that *T. butleri* is ecologically very similar, being adapted to earthworm prey and able to withstand drought. Possibly the character suite that aids in the utilization of earthworm prey (Catling and Freedman 1979) is also functionally useful in drought avoidance. For example, a scent-oriented approach to foraging may increase efficiency of capturing earthworms, (which are most likely to be available in the dark). Through allowing nocturnal activity and facilitating aggregation, it may also enhance drought avoidance. Similarly, it is possible that small size and seasonal activity both increase the efficiency of feeding on earthworms, and at the same time the former may make hiding easier, while the latter permits drought avoidance by summer aestivation.

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Food and Feeding Behavior of Sympatric Snakes at Amherstburg, Ontario

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Three species of snakes inhabiting the same small area were found to have different diets, based on regurgitations induced by belly massage. Butler's Garter Snake (*Thamnophis butleri*) preyed almost exclusively on earthworms, while the Eastern Garter Snake (*T. s. sirtalis*) took earthworms and anurans in approximately equal frequency. The Brown Snake (*Storeria dekayi*) fed primarily on slugs, but also ate earthworms. These described diets are also apparently characteristic of each snake outside the area of sympatry. The Western Chorus Frog (*Pseudacris t. triseriata*) is reported for the first time as prey of *T. butleri*, and represents only the second record of this snake taking a frog. Experiments with adult *T. butleri* and *T. s. sirtalis* from the study area suggested that *T. butleri* had a superior ability in locating and capturing earthworms. Thus, different diets may at least be partially explained by differences in adaptation to various prey species. The differences among the three snakes in size distribution and in time of foraging may also contribute to the different diets observed. *Thamnophis butleri* is apparently also adapted to feeding on leeches, and these were probably the principal constituent of its diet in Ontario prior to the introduction of Palaearctic earthworms.

Key Words: Butler's Garter Snake, *Thamnophis butleri*, Eastern Garter Snake, *Thamnophis sirtalis sirtalis*, Brown Snake, *Storeria dekayi*, food, feeding behavior, adaptation, southwestern Ontario.

Some studies of closely related snake species in sympatry have shown resource partitioning with respect to diet while others have not (Gregory 1978). White and Kolb (1974) associated differences in the diets of sympatric Garter Snakes (*Thamnophis* spp.) with differences in prey availability in the different habitats utilized by the different snake species. Carpenter (1952) observed that the coexistence of different snake species at a particular site (i.e., local sympatry) offers an opportunity to observe differences between species that are largely independent of prey availability. Variation in diet among closely related sympatric snakes could result from innate differences in feeding behavior (Burghardt 1969, 1970), but few studies have attempted to establish such a relationship (Gregory 1978).

Herein we present data on food and feeding behavior of Butler's Garter Snake (*Thamnophis butleri*), the Eastern Garter Snake (*Thamnophis s. sirtalis*), and the Brown Snake (*Storeria dekayi*). There are few published data on the food of these snakes in Canada, and no previous studies compare their diets in an area of local sympatry. In addition, some of the factors potentially affecting prey utilization are considered.

Methods

Both the study area and our overall approach in studying these sympatric snake species were described previously (Freedman and Catling 1978). With the exception of a few pregnant females, all captured snakes which were distended as a result of recent feeding were induced to regurgitate by massaging the belly. The prey species were then preserved in 70% ethanol for later identification. All data were collected during a series of visits to the study area in the spring and summer of 1976 (14 and 30 May, 15 June, 10 and 24 July).

Because the literature suggests that *T. butleri* is specialized to earthworm prey, an experiment was designed to evaluate the relative abilities of adult *T. butleri* and *T. s. sirtalis* in capturing earthworms (*Lumbricus terrestris*). The experiment was based on the time required to locate and attack prey in a standardized situation. Snakes of both species, kept at room temperature, were fed as much as they would eat over a period of several days, and then not fed for about 25 d. After this period, a snake was introduced into a 0.75-m^2 terrarium, which had 10 cm of soil, a loose grass sward, and cover of flat rocks and sticks. Approximately 50 adult earthworms were kept in this terrarium at all times. A half hour prior to the experiments, the terrarium was heavily watered, bringing worms near the surface. A snake was then introduced, and the time taken to locate and capture one earthworm was recorded, allowing up to 15 min. An individual snake was tested only once and all snakes tested

TABLE 1 — Numbers of snakes of each of three species regurgitating various prey items, at the Amherstburg study area

Prey	*Thamnophis butleri*	*Thamnophis s. sirtalis*	*Storeria d. dekayi*
Earthworms			
(various species[a])	27	6	3
Frogs and toads			
Rana pipiens (Northern Leopard Frog)	—	2	—
Pseudacris triseriata triseriata (Western Chorus Frog)	1	—	—
Bufo americanus americanus (American Toad)	—	3	—
Slugs			
Species not determined	—	—	7

[a]See Table 2 for earthworm species utilized by *T. butleri*. All regurgitations from *T. s. sirtalis* were *Lumbricus terrestris*. The earthworm species collected from *S. d. dekayi* were not determined.

had been collected randomly from the Amherstburg study area. Snakes were introduced to the test situation many times prior to the "test," when prey was actually available. All snakes utilized in the experiment were of comparable total length (35–45 cm), and included both males and females: 23 *T. butleri* and 21 *T. s. sirtalis*.

Results and Discussion

Prey of Three Sympatric Snakes

The prey items regurgitated by each of the three species of snakes are summarized in Table 1. Earthworms, regurgitated by 27 of 28 *T. butleri*, appeared to be the most important prey of this snake in our study area. The species of earthworms regurgitated by *T. butleri* are listed in Table 2. *Lumbricus terrestris* and *Allolobophora chlorictica* were regurgitated most frequently. *Lumbricus terrestris* is a relatively large earthworm and may have been over-represented because its larger size makes body distention more obvious and possibly increased the time necessary for digestion. *Aporrectodea trapezoides*, for which we had one food record (taken by 4% of *T. butleri* regurgitating food), has not been reported elsewhere as food. *Aporrectodea* (*Eisenia*) *rosea* was not recorded as a prey item in our study area although it was present there.

Juveniles, aclitellate adults, and clitellate adults were all represented in the regurgitated sample (Table 2) but the sample size was too small to test for significance. Evidence for other predators of earthworms (the European Mole, *Talpa europea*, and the American Woodcock, *Philohela minor*) suggested that the non-clitellate age class was preferred (Reynolds 1977a, b and personal communication).

The Western Chorus Frog (*Pseudacris t. triseriata*, Table 1) taken from a small *T. butleri* (total length 16 cm) on 23 July 1976 was only the second record of a frog being a prey item of *T. butleri* under natural circumstances. The only other record of *T. butleri* ingesting any anuran in the field was that of Test (1958), who reported a young snake (16.5 cm) that regurgitated an adult Spring Peeper (*Hyla crucifer*).

Although Wright and Wright (1957) recorded frogs, insects, field mice, and salamanders among the food items of *T. butleri*, critical study of the food of this

TABLE 2 — The number of earthworms (juveniles – aclitellate adults – clitellate adults = total number) regurgitated by 15 *Thamnophis butleri* (for definitions of the age classification formula, see Reynolds 1977a)

Earthworm species[a]	Number of earthworms	Number of snakes contributing
Allolobophora chlorotica	3 – 2 – 5 = (10)	4
Aporrectodea trapezoides	2 – 1 – 0 = (3)	1
Aporrectodea tuberculata	0 – 0 – 1 = (1)	1
Aporrectodea sp.	0 – 0 – 1 = (1)	1
Lumbricus terrestris	2 – 0 – 3 = (5)	5
Lumbricus sp.	2 – 0 – 0 = (2)	3[b]

[a]Identifications by J. W. Reynolds, University of New Brunswick.
[b]The discrepancy in number of snakes here results from the fact that not all regurgitated earthworms could be assigned to a particular age classification.

species indicates that earthworms and leeches are predominant in the diet under natural circumstances. Conant (1938) reported that only earthworms were disgorged by wild snakes, and Ruthven (1911) recorded several leeches from the stomach of a specimen collected in Michigan. Carpenter (1952) found that *T. butleri* in his Michigan study area fed chiefly on earthworms (83%) and leeches (10%). Both Conant (1938) and Carpenter (1952) found that captive specimens would accept certain amphibians and chopped fish. Reynolds' (1977a) report of three species of earthworms from the stomachs of *T. butleri* from Essex and Lambton Counties, Ontario, included specimens from our Amherstburg study area. In another Ontario study, Casbourne et al. (1977, unpublished report to the Ontario Ministry of the Environment, Toronto) found that the diet of *T. butleri* under natural circumstances was 90% earthworms (four species), 7% leeches (one species), and 2% Chorus Frog (*Pseudacris t. triseriata*), the latter representing the specimen from our study area. These data appear to be based on forced regurgitations of 37 snakes.

In our study area *T. s. sirtalis* preyed on earthworms, frogs, and toads (Table 1), the latter representing the greater proportion of food volume. The only earthworm species identified was *Lumbricus terrestris*, smaller worms being badly decomposed. All toads consumed were large adults at least 7 cm long, taken by snakes of various sizes and sexes (total lengths: 65-cm female, 71-cm male, 34-cm female), one in late May and two in July. The frogs were also adults consumed by medium-sized snakes (ca. 60 cm long).

Early reference to the diet of *T. s. sirtalis* records earthworms, frogs, toads, and fish (Hamilton 1951), but in many cases the food items are merely listed without any attempt to rank them in terms of importance. Lagler and Salyer (1945) showed that *T. s. sirtalis* near fish-rearing ponds rivalled the Northern Water Snake (*Natrix s. sipedon*) as a successful fish predator. Fish comprised only 6% of volume and 11% frequency in snakes from near natural waters, but around hatchery ponds fish constituted 40% by volume and 38% frequency of occurrence. This suggests that availability is a factor in determining food habits, and that *T. s. sirtalis* is versatile in its feeding behavior. Although Lagler and Salyer (1945) found that earthworms (species not given) were taken most frequently under natural circumstances, the percentage of total food volume contributed by frogs and toads together far exceeded that contributed by earthworms. Hamilton (1951) in his review stated that all reports indicate that earthworms (most of which are *Lumbricus terrestris*) are the most important food. They occurred in more than 60% of the 241 snakes examined by Hamilton, and represented 63% by volume and 57% frequency, whereas total amphibians accounted for 30% of total food volume and 28% frequency. Furthermore, Hamilton suggested that earthworms are digested more quickly than amphibians so that they may actually be under-represented in regurgitation samples. At a site in Kansas, Fitch (1965) found that amphibians were the most important food items of *T. s. sirtalis*, with earthworms representing a relatively small percentage and taken only by juvenile snakes. Gregory and Stewart (1975) found that Wood Frogs (*Rana sylvatica*) were dominant in the diet of *T. s. parietalis* in the Interlake region of Manitoba.

In situations where *T. s. sirtalis* and *butleri* occur together, either locally or in overall distribution, it has been shown that *T. s. sirtalis* relies more on amphibians and is more of a generalist, whereas *T. butleri* feeds almost entirely on earthworms and leeches (Carpenter 1952; Casbourne et al. *op. cit.*). Our findings are in general agreement with this literature.

Slugs were predominant in regurgitated samples from *S. dekayi* (Table 1). Generally, all authors agree that *S. dekayi* feeds on slugs and earthworms, and to a lesser extent on insects (Conant 1938; Wright and Wright 1957; Logier 1958). Slugs appear to be more important than earthworms. Judd's (1954) sample of 10 snakes from London, Ontario contained a predominance of slugs, followed by worms and a few insects.

Differences in Prey Utilization

It is apparent that the different snake species at Amherstburg were utilizing somewhat different food resources. According to the available literature, the prey reported here for each species is also characteristic outside the area of sympatry. Although the differences may reflect a means of competition avoidance, there is no evidence for any localized niche shifts.

The differences in diet among the three snake species could have resulted from (1) differences in size among snake species as related to size of prey, (2) different times of foraging by the different snake species as related to time of activity of prey, (3) different feeding behaviors among snake species, including differences in physiological and behavioral adaptations to various prey species, (4) variation in local distribution and abundance of snakes and/or prey, and (5) competitive interactions. The first three of these factors are more or less "innate" and are considered here, while the last two factors are largely external and are considered in another paper (Catling and Freedman 1980).

1) Size limitations

Thamnophis butleri and *S. dekayi* are relatively small snakes, with total lengths averaging about 38

and 30 cm long, respectively, in our study area, while *T. s. sirtalis* is medium-sized, averaging 52 cm long (Freedman and Catling 1978). The relatively smaller size of *T. butleri* and *S. dekayi* might allow more efficient utilization of small prey such as slugs or earthworms, than is normally possible for the larger *T. s. sirtalis*. Possibly smaller size is adaptive not only for capturing relatively small prey, but also in that smaller snakes do not have to encounter as many small dispersed food packages as larger snakes in order to survive. *Thamnophis s. sirtalis* is able to utilize larger amphibian prey not available to smaller snakes. Burghardt (1969) thought that factors other than preference were involved in restricting *T. butleri* to worms under natural circumstances: " . . . the species' stocky build, for instance may render it incapable of catching quick-moving prey, or at least less efficient than competitors." It is clear that size differences among the three snakes could contribute to resource partitioning.

2) Time of foraging

A snake might encounter certain prey animals more frequently as a result of its foraging at the same time that the prey is active.

The differences in frequency of sightings at different times of the year are striking for small snakes known to feed on earthworms. Conant (1938, 1943) found *T. butleri, S. dekayi*, and *Natrix kirtlandi* (all earthworm feeders) to be most often seen in April and October. Gates (1961) has shown that earthworms are most active in the spring and fall in the humid continental climate of northeastern North America. Similarly, in our study area earthworms became scarce in June and July. A snake with a seasonal activity pattern corresponding to that of earthworms might be better adapted to utilizing this prey.

Logier (1939, 1958) found that during hot weather in early July, *T. butleri* was active only from sunset until dark. Conant (1943) speculated that the worm-eating Kirtland's Water Snake (*Natrix kirtlandi*) does most of its foraging at night when there is less danger of desiccation, and when earthworms are also likely to be out in the open. Wright and Wright (1957) suggested that *S. dekayi* is largely nocturnal. A capacity for activity at lower temperatures might also be useful to nocturnal snakes, especially those most active in early spring and late fall.

Our observations suggested that *S. dekayi* and the Eastern Fox Snake, *Elaphe vulpina gloydi*, were active primarily at night; we found them only under cover during the day. *Thamnophis butleri* was occasionally seen in the open during the day in early spring but never in summer. *Thamnophis s. sirtalis* was often seen active during the day in midsummer visits. Snakes apparently depending to a large extent on visual food orientation (e.g., *T. s. sirtalis*, see below) would have to hunt during the daylight hours. Hamilton (1951) suggested that *T. s. sirtalis* generally captures earthworms during the day.

3) Feeding behavior

Our general observations of captive snakes (40 *T. butleri* from various localities in Ontario and 30 *T. s. sirtalis* also from several localities) revealed qualitative differences in feeding behavior. *Thamnophis butleri* appears to be largely scent-oriented, searching the surface of the ground or even "burrowing," with tongue-flicking or nose-pressing to prey being frequent. Underwater search for leeches is much more active, with thrashing and lateral sweeping of the head. *Thamnophis s. sirtalis* is less inclined to probe the ground or to submerge underwater, its head being held high, with much tongue-flicking and attraction to movement of prey, this latter suggesting a more visual approach to hunting. Similar qualitative observations have been made by others (J. Planck and J. Planck 1977, unpublished report to the Department of Supplies and Services, Ottawa; Casbourne et al. *op. cit.*).

Carpenter (1952) speculated that food preferences (i.e., the tendency to select certain types of prey more frequently) were determined by inherited behavior patterns. Burghardt (1969) described experiments with naïve newborn young of various species of *Thamnophis* which suggested inherited differences between some species in feeding behavior based on perception of prey. Scoring on the basis of frequency and latency of attack, as well as tongue-flicking, Burghardt found that *T. butleri* responded more to earthworms and leeches and less to amphibians than *T. s. sirtalis*. The differences, however, were not great and the naïve young of *T. butleri* also responded relatively well to amphibians and fish, which are rarely taken under natural circumstances.

Casbourne et al. (*op. cit.*), experimenting with five *T. s. sirtalis* and 13 *T. butleri*, did not reveal any significant difference in the time taken to contact various prey items. In their experiments both species contacted earthworms more rapidly than any other prey. Using tongue-flicking as an indication of sensitivity to prey they presented some evidence suggesting that *T. butleri* reacts most strongly to leeches, while *T. s. sirtalis* reacts most strongly to fish. There are, however, certain problems with the interpretation of tongue-flicking data (Carr and Gregory 1976; Gregory 1978), and detailed comparisons using these data seem undesirable.

Our experiments with snakes from the Amherstburg site demonstrated that *T. butleri* located and attacked earthworms (*Lumbricus terrestris*) more quickly than does *T. s. sirtalis*, and always did so within the allotted 15 min, whereas *T. s. sirtalis* was

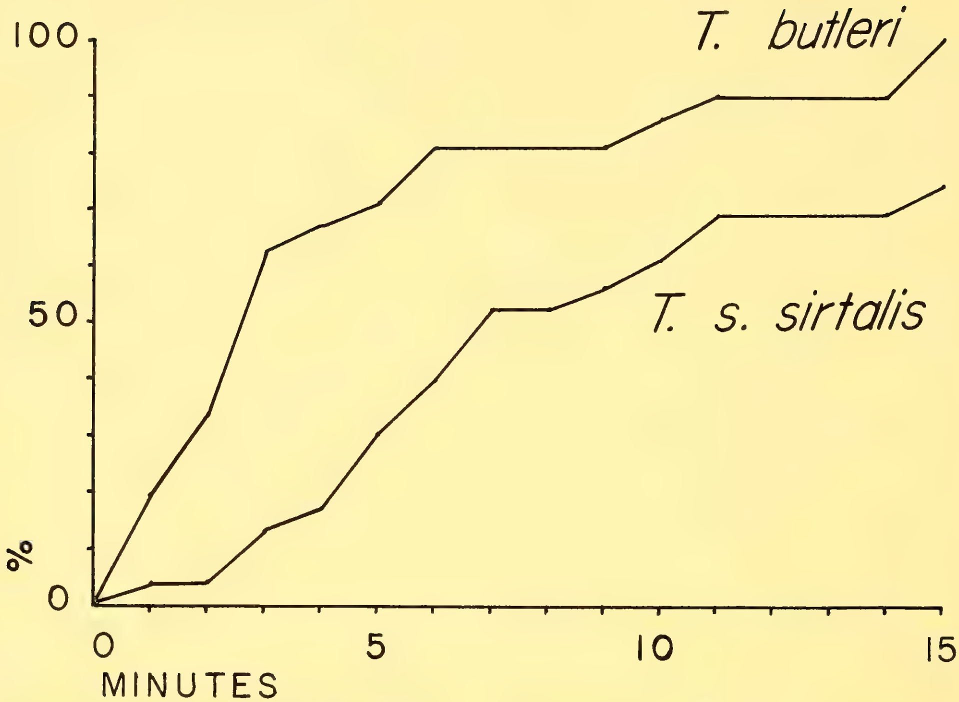

FIGURE 1. The success (cumulative percentage as a function of time) of 21 *T. butleri* and 23 *T. s. sirtalis* in locating and attacking earthworms (*Lumbricus terrestris*).

much slower, and in 26% of trials was unsuccessful within the 15-min time span (Figure 1). *Thamnophis butleri* appeared to follow the scent of worms down holes, and frequently burrowed down worm holes and captured earthworms below ground. In contrast, *T. s. sirtalis* never "burrowed" and often located prey visually, lunging at it when it moved.

Based on the preceding discussion, it seems reasonable to consider *T. butleri* as better adapted to feeding on earthworms and leeches than is *T. s. sirtalis*, which is better adapted to amphibian prey. Planck and Planck (*op. cit.*) have indicated that, on the basis of their survey, reliance upon earthworms as the dietary mainstay is foremost among the habitat requirements of *T. butleri*, and indeed all of the literature (see above) indicates that earthworms are very important to this snake. But one cannot overlook the unusual sensitivity to leeches possessed by these snakes. In extensive temporary marshland and mesic prairie where prey in the form of leeches is available, *T. butleri* may have an advantage in the use of this prey over other species of snakes. This latter situation may represent the original situation in Ontario prior to settlement. It appears that there are no native earthworms in Ontario, and at the Amherstburg site *T. butleri* is dependent upon the Palaearctic earthworms introduced by man (Reynolds 1977a,b). Without the presence of this introduced earthworm prey, it would probably be a much rarer species in Canada, taking into consideration the widespread destruction of wet meadow and marshland habitats. Native earthworms may exist in other parts of its range and may have always been important prey items in these areas. Earthworm prey is not necessarily to be considered a recent phenomenon, although the evidence suggests that this may be the case in Ontario.

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Onzième Inventaire et Analyse des Fluctuations des Populations d'Oiseaux marins dans les Refuges de la Côte Nord du Golfe Saint-Laurent

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Chapdelaine, Gilles. 1980. Onzième inventaire et analyse des fluctuations des populations d'oiseaux marins dans les refuges de la Côte Nord du golfe Saint-Laurent. Canadian Field-Naturalist 94(1): 34–42.

Les résultats du onzième inventaire des oiseaux marins des refuges de la Côte Nord du golfe Saint-Laurent démontrent que les populations d'alcidés continuent de diminuer tandis que les laridés augmentent. Parmi les alcidés, le Gode et le Macareux moine sont les deux espèces les plus sérieusement menacées alors que parmi les laridés, la Mouette tridactyle, le Goéland à bec cerclé et les Sternes commune et arctique augmentent. Les causes de diminution du Macareux moine sont attribuables en partie au braconnage et au dérangement humain tandis que chez le Gode il apparaît probable que la pollution par le pétrole dans son aire d'hivernage et un taux élevé de PCB dans les oeufs aient contribué à sa diminution. L'augmentation de la Mouette tridactyle serait attribuable à une abondance de nourriture et celle du Goéland à bec cerclé et des Sternes commune et arctique aux déplacements de colonies de l'extérieur vers l'intérieur des refuges.

Mots clés: oiseaux marins, fluctuations des populations, refuges, golfe Saint-Laurent, Alcidae, Laridae.

The eleventh census of seabirds nesting in the Migratory Bird Sanctuaries of the North Shore of the Gulf of St. Lawrence showed that alcid populations continued to decline and larids to increase. Razorbills and puffins showed the most serious decreases while Black-legged Kittiwakes, Ring-billed Gulls, and Common and Arctic Terns increased markedly. The decline of puffins is attributed in part to poaching and human disturbance while Razorbills appear to have decreased owing to oil spills on the wintering grounds and to contamination of the eggs by PCBs. The population growth of the Black-legged Kittiwake can be explained by an abundant food supply, while the increase in Ring-billed Gull, Common and Arctic Terns is attributed to immigration from non-refuge sites nearby.

Key Words: seabirds, population dynamics, sanctuaries, Gulf of St. Lawrence, Alcidae, Laridae.

Le présent travail s'inscrit dans le cadre d'un programme d'inventaires quinquennaux qui ont débuté en 1925 dans les refuges d'oiseaux migrateurs de la Côte Nord du golfe Saint-Laurent. Ces dénombrements ont pour but de mesurer les effectifs des populations d'oiseaux marins à tous les cinq ans (Lewis 1925, 1931, 1937, 1942; Hewitt 1950; Nettleship et Lock 1973). Malgré certaines imperfections dans les méthodes appliquées avant 1972 (Nettleship et Lock 1973), ces recensements ont permis de déceler les tendances des fluctuations des populations d'oiseaux marins depuis plus d'un demi-siècle.

L'inventaire de 1977 avait pour objectif principal d'évaluer les effectifs de chacune des espèces d'oiseaux marins que l'on retrouve à l'intérieur des refuges* (figure 1) et de les comparer avec ceux de 1972. De plus, on a complété une revue détaillée des fluctuations des populations de 1925 à 1977 (Chapdelaine, manuscrit non publié). Un extrait de cette révision fait partie de la présente étude.

Méthodes

Afin d'obtenir des résultats comparables, nous avons utilisé les techniques proposées par Nettleship (1976) (sauf pour les anatidés) lesquelles se résument de la façon suivante:

Gaviidés — On a effectué des dénombrements systématiques de nids de Huart à gorge rousse** autour des étangs des îles de chaque refuge.

Anatidés — On a estimé les populations d'Eider à duvet selon les méthodes suivantes: (1) dénombrements systématiques des nids quand le temps et la dimension des îles le permettent, (2) système de quadrats permettant de dériver une densité moyenne (couples/ha) qu'on extrapole à la superficie occupée par l'ensemble de la colonie pour les îles de grande dimension, (3) dans les refuges où on retrouve un très grand nombre d'îles (e.g., Watshishu, Baie des Loups,

*Les refuges des îles aux Bouleaux et de Mécatina ont été abandonnés en tant que refuge d'oiseaux migrateurs après 1972. Les îles aux Bouleaux furent inventoriées en 1978 dans le cadre d'un programme d'inventaire des oiseaux marins de l'archipel de Mingan.

**Les noms scientifiques des espèces d'oiseaux apparaissent dans le tableau 1.

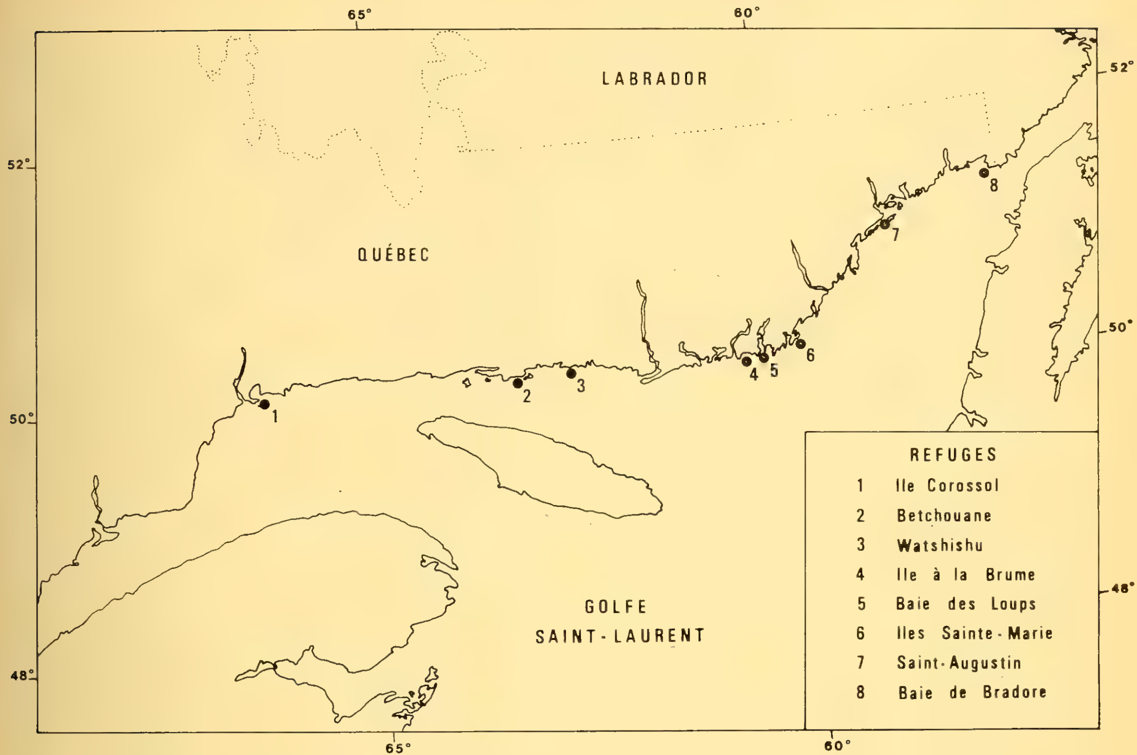

FIGURE 1. Localisation des refuges de la Côte Nord du golfe Saint-Laurent.

FIGURE 1. Location of the sanctuaries of the North Shore of the Gulf of St. Lawrence.

Saint-Augustin), on a dénombré tous les nids sur au moins 10% (50% pour Baie des Loups) de la superficie de l'ensemble des îles de chaque refuge et dérivé une densité moyenne extrapolée à la superficie totale de toutes les îles du refuge. On a établi les superficies à partir de relevés planimétriques sur des photographies aériennes à l'échelle 1:15 840.

Phalacrocoracidés — On a procédé à des dénombrements systématiques de nids du Grand Cormoran et du Cormoran à aigrettes, sauf dans le refuge de Corossol. A cet endroit les nids du Cormoran à aigrettes se trouvent dans le faîte des épinettes et furent photographiés à l'aide d'un appareil Hasselblad, muni d'une lentille 120 mm, à partir d'un hélicoptère Alouette. Par la suite, on a dénombré tous les nids sur des agrandissements couleur de 20 x 20 cm.

Laridés — Les techniques d'inventaire différaient selon les espèces, la nature des sites de nidification et la dimension des colonies: (1) dénombrements systématiques des nids (Goéland argenté, Goéland à bec cerclé, Mouette tridactyle, Sterne commune, Sterne arctique, Sterne caspienne), (2) on sélectionne des colonies dites "contrôlées" où le nombre de nids (Np) et le nombre d'adultes (Ni) sont déterminés et on dérive un facteur $K = Np/Ni$ permettant d'estimer le nombre de couples au sein des colonies où on observe seulement le nombre d'adultes présents (Goéland argenté, Goéland à bec cerclé, Sterne commune, Sterne arctique), (3) dénombrement des adultes seulement (Goéland à manteau noir). Etant donné qu'il est difficile et onéreux en temps de différencier la Sterne commune et la Sterne arctique dans les colonies mixtes, nous avons regroupé les résultats pour ces deux espèces.

Alcidés — On a procédé à des dénombrements systématiques d'oeufs dans la majorité des colonies de Gode et de Marmette commune. Nous avons utilisé la méthode des colonies "contrôlées" pour quelques colonies (5% du nombre total de Gode et de Marmette commune). Les populations de Guillemot noir furent estimées à partir des dénombrements d'oiseaux adultes autour des îles. D. Cairns a fourni des données sur la

distribution des couples de Guillemot noir dans deux îles du refuge des îles Sainte-Marie. Les colonies de Macareux moine de moindre importance (≤ 500 couples) furent l'objet de dénombrements systématiques des terriers actifs. Les colonies plus importantes furent inventoriées selon la méthode des quadrats alignés à l'intérieur desquels on enregistre le nombre de terriers actifs (voir Nettleship 1976, p. 22).

Résultats

Les résultats du tableau 1 montrent que le nombre total d'oiseaux dans les refuges de la Côte Nord a diminué depuis 1972 (50 600 à 46 283 individus). Alors que les laridés ont augmenté de 32%, les phalacrocoracidés et les alcidés ont connu des baisses respectives de 53% et 22%. Parmi les 15 espèces inventoriées, cinq ont connu des augmentations (Goéland à bec cerclé, Mouette tridactyle, Sternes commune et arctique, Marmette commune), quatre ont subi des baisses (Grand Cormoran, Cormoran à aigrettes, Gode, Macareux moine), quatre se sont maintenues (Goéland à manteau noir, Goéland argenté, Sterne caspienne, Guillemot noir) et finalement deux espèces (Huart à gorge rousse, Eider à duvet) ne peuvent être comparées à cause des dénombrements incomplets de 1972.

Le *Refuge de l'île Corossol* (visité le 8 juin) semble en excellente condition. La population de Mouette tridactyle a doublé ses effectifs. La diminution du Cormoran à aigrettes serait vraisemblablement attribuable à l'émigration d'une partie de la colonie vers l'île Petite Basque située à 5 km au nord du refuge. Des données d'inventaires de 1976 (Chapdelaine et P. Dupuis, communication personelle) indiquent qu'il n'y avait pas de colonie de cette espèce sur l'île Petite Basque. Or, en 1977 nous y avons dénombré une colonie de 62 nids. Ce nombre correspond à peu près aux pertes subies par la colonie de Corossol. Le Goéland argenté accuse une baisse de l'ordre de 18% et tout comme dans la plupart des autres refuges la population de Gode a diminué. Le Goéland à manteau noir et le Guillemot noir maintiennent leurs effectifs.

Le *Refuge de Betchouane* (visité le 14 juin) démontrait des signes évidents de braconnage. Les alcidés, dont les représentants sont le Gode et le Macareux moine, connaissent des baisses sérieuses. Les faits les plus marquants furent les retours du Goéland à bec cerclé et de la Mouette tridactyle. Les dernières mentions de nidification de ces espèces dans Betchouane remontent à 1965 (Moisan et Fyfe 1967).

Watshishu (visité le 14 juin) fut déclaré refuge à cause de sa population d'Eider à duvet: "This sanctuary is predominantly the home of the famous Eider Ducks" (Lewis 1925). Malheureusement, les effectifs de cette espèce sont passés de 4000 individus en 1930 (Lewis 1931) à 296 en 1977. Il est probable que la chasse illégale et le pillage des oeufs aient contribué à cette diminution. Parmi les autres espèces, on note l'augmentation du Goéland argenté, des Sternes commune et arctique et du Guillemot noir. Le Cormoran à aigrettes, le Goéland à manteau noir et le Gode ont connu une réduction de leurs effectifs.

L'augmentation des effectifs totaux du *Refuge de l'île à la Brume* (visité le 17 juin) est attribuable aux laridés. Le Gode et le Guillemot noir ont maintenu de faibles effectifs. Depuis 1955, les populations d'alcidés de ce refuge ont été réduites à presque rien à cause semble-t-il de la cueillette illégale des oeufs.

Le *Refuge de Baie des Loups* (visité les 21 et 22 juin) a montré d'importants changements au sein de sa population d'alcidés. Les effectifs de la Marmette commune ont diminué de 83%, ceux du Gode de 48% et du Macareux moine de 40%. Les alcidés comptent pour 97% de la diminution des effectifs totaux du refuge. Les autres espèces qui enregistrent des baisses sont le Grand Cormoran, le Cormoran à aigrettes et le Goéland argenté. Ce refuge s'avère le plus important pour l'Eider à duvet bien que la densité moyenne des nids ne soit que de 2 couples/ha. Nettleship (manuscrit non publié) mentionnait que l'état de ce refuge "appears to be in fair shape even though there is no resident warden at Wolf Bay." En 1977, on ne peut en dire autant. Notre inventaire révèle une diminution de 38% des effectifs totaux et nous a permis d'observer de nombreux indices de braconnage.

Le *Refuge des îles Sainte-Marie* (visité les 15, 16, 23 et 24 juin) dépasse tous les autres refuges au point de vue abondance et diversité. C'est la première fois que la Mouette tridactyle niche dans ce refuge. Au total, 24 couples se trouvaient sur les falaises de l'île Cliff. On a obtenu des hausses pour le Macareux moine et la Marmette commune. Toutefois, ces augmentations seraient probablement moins importantes si l'équipe d'inventaire de 1972 avait oeuvré sous de meilleures conditions climatiques et avait pu fournir des dénombrements plus complets et plus détaillés pour ces deux espèces (Nettleship, manuscrit non publié). En contre partie, d'autres espèces ont subi des pertes assez considérables. Tel est le cas du Grand Cormoran, du Cormoran à aigrettes, du Goéland argenté et du Gode. Ce refuge bien qu'il soit relativement bien gardé reçoit aussi la visite des pilleurs de nids (G. Jones et D. Cairns, communication personelle).

Le *Refuge de Saint-Augustin* (visité le 26 juin) est avant tout celui des laridés (90% des effectifs totaux du refuge). L'augmentation apparente du nombre total d'oiseaux est due principalement à la méthode de travail que nous avons utilisée en 1977. En 1972, la technique consistait à dénombrer les oiseaux le long d'un transect parcouru en bateau (Nettleship, manuscrit non publié). Cette technique fournit un indice

TABLE AU 1—Inventaire des oiseaux marins (nombre d'individus) dans les refuges de la Côte Nord du golfe Saint-Laurent 1972[a] et 1977
TABLE 1—Census of seabirds (number of individuals) in the bird sanctuaries of the North Shore of the Gulf of St. Lawrance 1972[a] and 1977

Espèces	Ile Corossol		Betchouane		Watshishu		Ile à la Brume		Baie des Loups		Iles Sainte-Marie		Saint-Augustin		Baie de Bradore		Totaux	
	1972	1977	1972	1977	1972	1977	1972	1977	1972	1977	1972	1977	1972	1977	1972	1977	1972	1977
Pétrel cul-blanc, *Oceanodroma leucorhoa*									+	+							+	+
Grand Cormoran, *Phalacrocorax carbo*								2[b]	24		440	214					464	214
Cormoran à aigrettes, *Phalacrocorax auritus*	330	216	3[b]	5[b]	155	98		4[b]	120	16	320	122	3[b]				925	452
Goéland à manteau noir, *Larus marinus*	55	66	70	75	295	110	135	26	240	535	450	524	155	54	2	2	1402	1383
Goéland argenté, *Larus argentatus*	3600	2940	890	302	25	277	125	250	730	424	2205	540	2000	5356			9575	10099
Goéland à bec cerclé, *Larus delawarensis*				1038		2	3	122					445	554			448	1716
Mouette tridactyle, *Rissa tridactyla*	1830	3466		12			1[b]					48	5[b]	100[b]			1830	3526
Sterne commune et arctique, *Sterna hirundo* et *S. paradisaea*					350	620	50	102			20	88	215	660			635	1470
Sterne caspienne, *Sterna caspia*							2	3									2	3
Gode, *Alca torda*	130	80	100	22	21	9	4	7	2295	1190	1765	1192	5[b]		+	452	4315	2952
Marmette commune, *Uria aalge*	4	3							1510	246	4120	8986	1[b]				5634	9235
Guillemot noir, *Cepphus grylle*	20	24			6	46	55	47	61	47	330	342	31	11			503	517
Macareux moine, *Fratercula arctica*			190	88		2[b]			9510	5652	600	1546	9[b]		14540	7430	24840	14716
Total (1972 vs. 1977)	5969	6795	1250	1537	852	1153	374	567	14490	8110	10250	13602	2846	6635	14542	7884	50573	46283
Huart à gorge rousse, *Gavia stellata*					+[b]		+	4	+	6	+	28	+	4			+	42
Eider à duvet *Somateria mollissima*	+	292	+	8	+	296	+	352	+	826	+	382	+	692			+	2848
Grand total (1977)		7087		1545		1449		923		8942		14012		7331		7884		49173

[a] = Données provenant de Nettleship et Lock (1973).
[b] = Cette espèce ne niche pas dans le refuge et n'est pas considéré dans le total comparé 1972–1977.
+ = Présent mais aucun dénombrement pour estimer la population.

[a] = From Nettleship and Lock (1973).
[b] = This species doesn't nest in the sanctuary and not included in totals for 1972–1977 comparison.
+ = Present but no count to estimate the total population.

d'abondance mais ne permet pas d'estimer la population nicheuse totale. En 1977, nous avons couvert plusieurs îles au sol en dénombrant systématiquement tous les nids de chaque espèce. Par la suite, des facteurs de correction furent utilisés pour estimer les populations des îles où le nombre d'individus présents (Ni) était connu. Donc, nous croyons que notre inventaire reflète mieux la population nicheuse totale de ce refuge.

Dans le *Refuge de la Baie de Bradore* (visité le 29 juin) la population de Macareux moine a connu une baisse de l'ordre de 45% depuis 1972. Les effectifs de l'île aux Perroquets sont passés de 4625 à 3097 couples et ceux de l'île Greenly de 2645 à 618 couples. L'abattage d'oiseaux au sein des colonies, la capture d'Alcidés (Gode et Macareux moine) dans les filets de pêche tendus près des îles, le dérangement continuel aux abords des colonies (va-et-vient des embarcations motorisées) pourraient s'avérer des facteurs importants dans la diminution du Macareux moine. Malgré l'impossibilité de comparer les effectifs de la population de Gode en 1977 avec ceux de 1972, il ressort que cette espèce serait victime des mêmes préjudices que le Macareux moine.

Afin de mieux évaluer les changements intervenus dans les refuges depuis leur création, nous avons rassemblé les résultats d'inventaires de 1925 à 1977. La figure 2 présente les flucuations du nombre total d'oi-

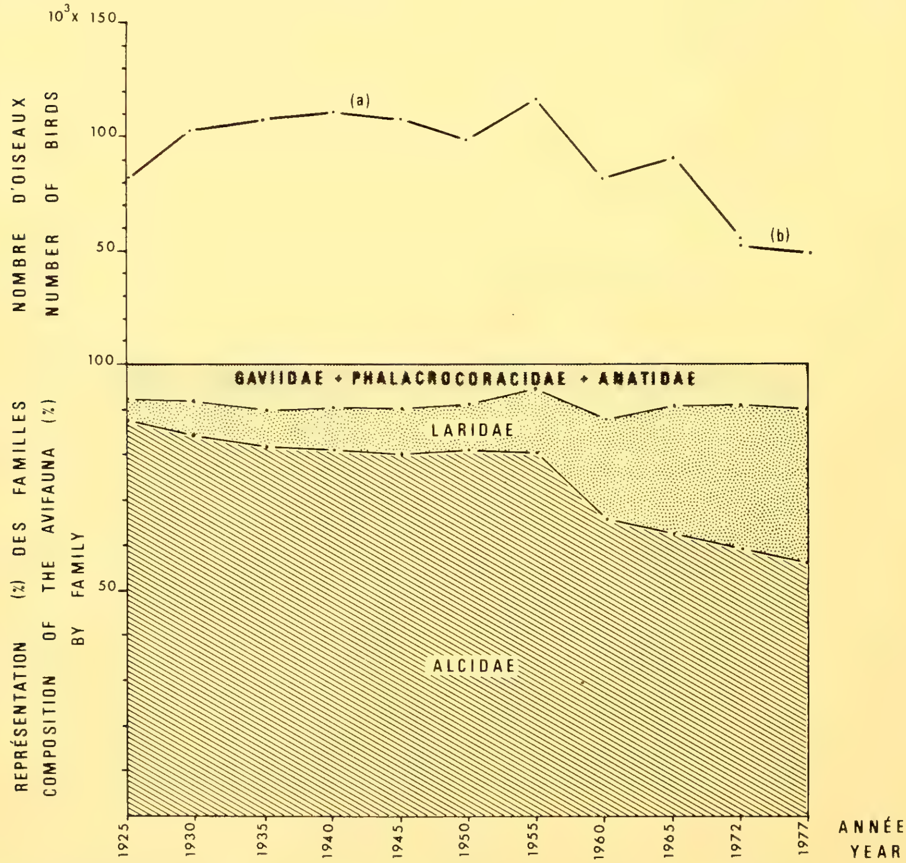

FIGURE 2. Partie supérieure, variation du nombre total d'oiseaux aquatiques dans les refuges de la Côte Nord du golfe Saint-Laurent; partie inférieure, variation de la représentation des familles: (a) concerne 10 refuges et (b) huit refuges. L'abandon de deux refuges après 1972 nécessitait un réajustement de la courbe.

FIGURE 2. Upper section, variation of the total number of aquatic birds of the North Shore of the Gulf of St. Lawrence; lower section, composition of the avifauna by family: (a) represents variation for 10 sanctuaries and (b) eight sanctuaries. Censuses of two sanctuaries were cancelled after 1972.

seaux et les changements intervenus dans la représentation des familles. Dans l'ensemble, on note deux tendances des effectifs totaux: (1) une faible augmentation des populations entre 1925 et 1955, (2) une baisse considérable entre 1955 et 1977. Au niveau des familles, on remarque une nette augmentation des laridés et une diminution des alcidés. Deux espèces en particulier ont contribué à rehausser la représentation des laridés. La première est le Goéland argenté qui a démontré un taux d'accroissement annuel de 5,9% (taux d'accroissement composé) entre 1955 et 1965 (figure 3). Les deux derniers inventaires révèlent un arrêt de cette augmentation. La seconde espèce est la Mouette tridactyle dont la population de l'île Coros-

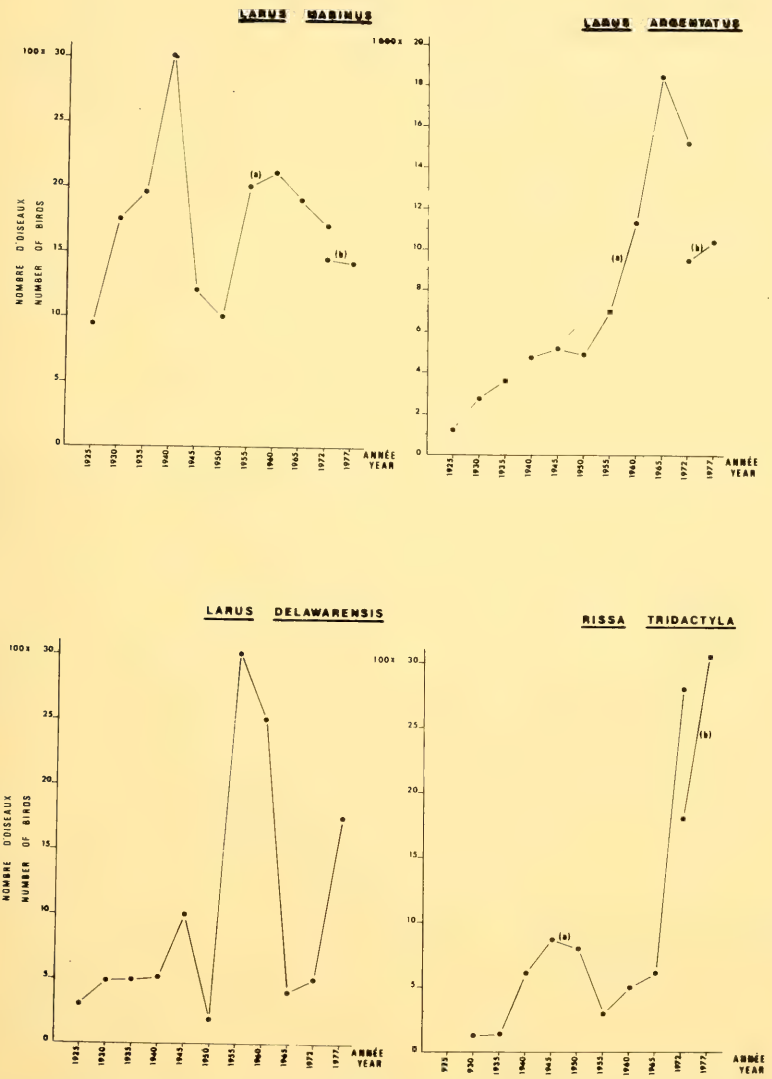

FIGURE 3. Variations du nombre d'individus de quatre espèces importantes de laridés dans les refuges de la Côte Nord du golfe Saint-Laurent entre 1925 et 1977: (a) concernent 10 refuges et (b) huit refuges. L'abandon des refuges des îles aux Bouleaux et de Mécatina après 1972 nécessitait un réajustement pour les espèces qui s'y trouvaient en grand nombre.

FIGURE 3. Changes in numbers of four important species of larids in sanctuaries of the North Shore of the Gulf of St. Lawrence between 1925 and 1977: (a) represents 10 sanctuaries and (b) eight sanctuaries. Censuses of îles aux Bouleaux and Mécantina sanctuaries were cancelled after 1972.

sol croît de façon exponentielle depuis 1955. Son taux d'accroissement annuel est de 12,8% (taux d'accroissement composé). En 1977, on assiste aussi à l'occupation de deux nouveaux sites de nidification: 24 couples dans le refuge des îles Sainte-Marie et 12 couples sur l'île du Lac (50°11′N, 60°04′Ô) situés entre le refuge de Baie des Loups et celui des îles Sainte-Marie. Des inventaires effectués en 1976 indiquent que la Mouette tridactyle ne nichait pas à ces deux endroits.

Parmi les alcidés, le Gode et le Macareux moine connaissent des diminutions marquées (figure 4). Par rapport aux effectifs maximums du passé on enregistre des pertes de l'ordre de 84% pour le Gode et de 80% pour le Macareux moine. La Marmette commune et le Guillemot noir ont aussi connu des baisses, mais le dernier inventaire démontre une stabilisation des effectifs du Guillemot noir et une remontée de la Marmette commune.

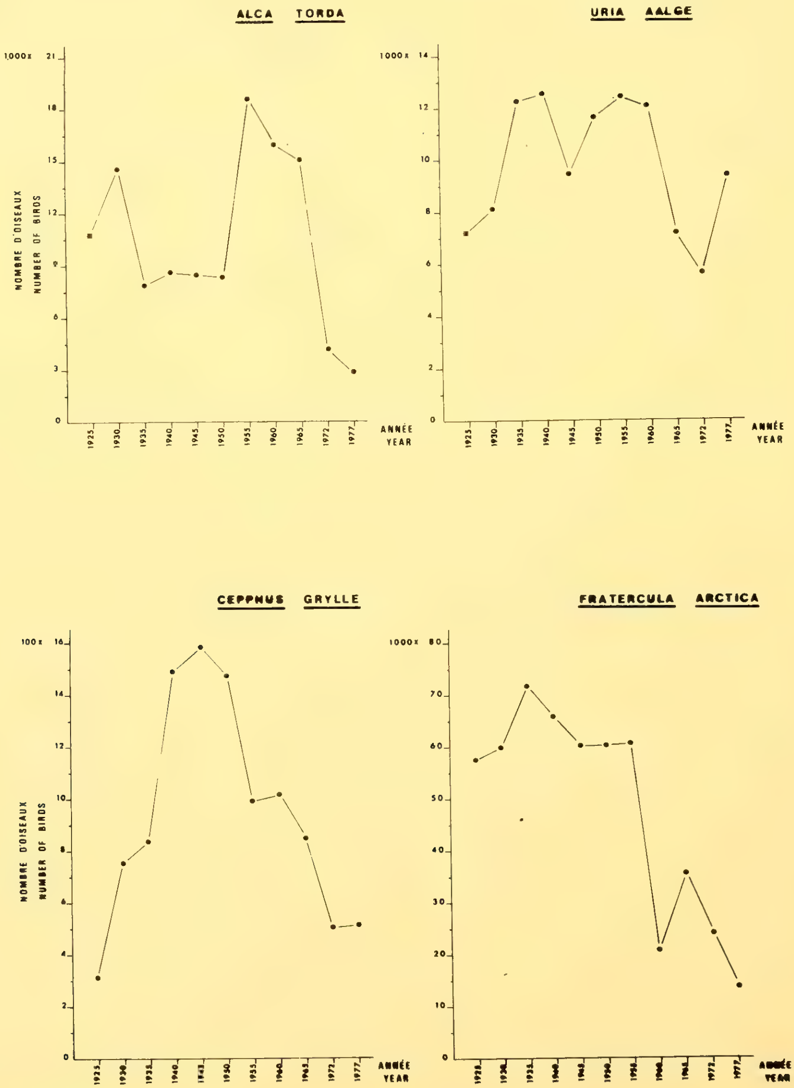

FIGURE 4. Variations du nombre d'individus de quatre espèces d'alcidés dans les refuges de la Côte Nord du golfe Saint-Laurent entre 1925 et 1977.

FIGURE 4. Changes in numbers of four alcids in the sanctuaries of the North Shore of the Gulf of St. Lawrence.

Discussion

Le présent inventaire peut être comparé à celui de 1972 en raison de la similitude des techniques utilisées. Les résultats font ressortir des changements substantiels intervenus au sein de chaque refuge sauf pour celui de Saint-Augustin où les résultats ne sont pas comparables pour la raison énoncée ci-dessus.

Les causes d'augmentation et de diminution des espèces ne peuvent pas être mises en évidence avec clarté et précision en raison de la carence d'études biologiques détaillées et spécifiques sur la reproduction, l'alimentation, la distribution dans les aires d'hivernage et l'impact de la pollution des eaux marines (pétrole, produits chimiques toxiques) sur ces populations. Cependant, nous croyons qu'il est justifié de soulever les remarques suivantes.

Parmi les laridés, l'augmentation de la Mouette tridactyle est réelle. Cette espèce connaît actuellement un accroissement de ses effectifs des deux côtés de l'Atlantique Nord (Cramp et al. 1974; Nettleship 1977). Les causes précises d'une telle augmentation restent à être élucidées bien que l'absence de prédateurs et une surabondance de nourriture soient suggérées (J. C. Coulson *dans* Cramp et al. 1974).

L'augmentation manifestée par les Sternes commune et arctique, et le Goéland à bec cerclé est réelle à l'intérieur des refuges, mais ne reflète pas nécessairement ce qui se passe ailleurs sur la Côte Nord. L'apport d'effectifs en provenance d'îles de l'extérieur des refuges est tout à fait plausible. Très souvent, à la suite du dérangement humain, des colonies entières de sternes changent de localité (Ludwig 1962; Cramp et al. 1974; Vaisänen 1973; Nisbet 1973). Pour obtenir une image réelle de la fluctuation des populations de sternes, il faudrait inventorier à intervalle régulier (tous les cinq ans par exemple) plusieurs autres colonies situées à l'extérieur des refuges. Selon les inventaires aériens effectués en 1976 (Chapdelaine et P. Dupuis, manuscrit non publié), seulement 14% des sternes de la Côte Nord se retrouvent à l'intérieur des refuges. Des déplacements annuels de colonies sont aussi observés pour le Goéland à bec cerclé (Lewis 1941).

La stabilisation des populations de Goéland argenté et la diminution au sein de certaines colonies (e.g., refuges de Corossol et de Baie des Loups) est un phénomène qui se manifeste depuis 1972. Nisbet (1978) mentionne que les populations de Goéland argenté ont diminué là où on enregistre une baisse dans les débarquements de poisson. Une telle situation amène une réduction de la disponibilité des déchets de poisson, source importante de nourriture pour les goélands. Des données du Ministère de l'Industrie et du Commerce (fournies par le Bureau de la Statistique du Québec) concernant la pêche commerciale sur la Côte Nord du golfe Saint-Laurent révèlent une diminution drastique de la quantité de poisson débarqué depuis 1971 (figure 5).

Parmi les alcidés, la diminution du Macareux moine nous apparaît comme étant liée directement au dérangement humain au sein des colonies de la Baie de Bradore qui ont déjà totalisé 87% (62 418 individus) des effectifs de la Côte Nord (Lewis 1937). Aujourd'hui, ces colonies comptent pour 50% (7884 individus) des effectifs de cette espèce. Quant à la population de Gode, rappelons que Bédard (1969) estimait la population de l'Atlantique Ouest à 42 200 individus dont plus de 38% nichaient dans les refuges de la Côte Nord. Plus récemment, on a estimé cette population à 38 132 (Nettleship 1977) dont seulement 8% se retrouvent maintenant dans les refuges. Les causes de cette importante diminution semblent multiples et inextricables. Cette espèce peut subir des pertes considérables par la pollution des eaux par le pétrole (Lloyd 1976). L'épanchement de mazout occasionné par le naufrage de l'*Argo Merchant* au large de l'île Nantucket (Massachusetts) en décembre 1976 pourrait bien être responsable de la perte d'un bon nombre d'oiseaux car cette zone fait partie de l'aire d'hivernage du Gode (Bédard 1969). Powers et Rumage (1978) rapportent que le Gode représentait 14% (n = 181) des carcasses d'oiseaux ramassés le long des plages de Nantucket Island et Martha's Vineyard à la suite de ce déversement. On a aussi signalé la présence de produits chimiques toxiques (PCB, DDE) en quantité appréciable dans des oeufs de Gode en provenance de la Côte Nord (Gilbertson et Reynolds 1974). Com-

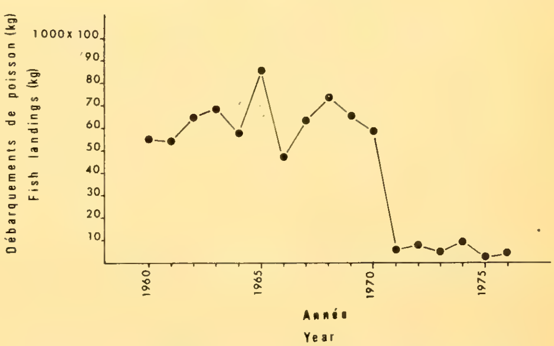

FIGURE 5. Comparaison par année de débarquements de poisson dans les ports de pêche de la Côte Nord du golfe Saint-Laurent depuis 1960. Données fournies par le Bureau de la Statistique du Ministère de l'Industrie et du Commerce.

FIGURE 5. Comparison by year of total fish landings in harbors of the North Shore of the Gulf of St. Lawrence since 1960. Data supplied by Bureau de la Statistique du Ministère de l'Industrie et du Commerce.

parativement aux niveaux enregistrés chez la Marmette commune et la Macareux moine, ces taux étaient plus élevés chez le Gode. Cependant, aucune étude précise sur la biologie de la reproduction de cette espèce ne nous permet de mesurer l'incidence de tels produits chimiques toxiques sur son taux net de productivité.

La diminution en nombre du Gode et du Macareux n'est pas un phénomène particulier à la Côte Nord. Cette tendance a aussi été signalée ailleurs dans l'Atlantique Nord par Lloyd (1976), Harris (1976) et Nettleship (1977). Toutefois le braconnage et le dérangement humain dans plusieurs colonies contribueraient à accentuer la diminution dans les refuges de la Côte Nord.

Suite à l'inventaire de 1977 nous appuyons les recommandations antérieures (Nettleship et Lock 1973) qui se résument à l'amélioration du système de gardiennage et la réalisation d'études biologiques sur les espèces les plus menacées.

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A Review of Factors Influencing Extralimital Occurrences of Clark's Nutcracker in Canada

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Of 67 occurrences of Clark's Nutcracker outside its normal range in Canada from 1904 to 1976, three quarters were in British Columbia and Alberta. Single birds were involved in 70% of the records. Approximately 85% of the total birds involved were recorded in the months from August to November. Synchrony between extralimital records in widely separated places in the same year occurred in 1919, 1960, 1965, 1969, 1972, and 1976. Recurring failures of coniferous seed crops in the normal range of the nutcracker and the passage of weather systems at the time of dispersal are the most likely factors influencing extralimital occurrences of Clark's Nutcracker. Several extralimital Canadian sightings were probably of birds that originated from the normal range in the western United States. There is a need for further study of seed crops of Whitebark Pine (*Pinus albicaulis*).

Key Words: Clark's Nutcracker, *Nucifraga columbiana*, eruptive dispersal, weather systems, conifer seed crops, Whitebark Pine, *Pinus albicaulis*, Canada.

Clark's Nutcracker (*Nucifraga columbiana*) is a permanent resident in the subalpine zone of the mountain ranges of western North America. Its normal Canadian range is not yet proved to extend into the northern half of British Columbia or Yukon Territory (Figure 1). Breeding occurs primarily above 1000 m (Munro and Cowan 1947) where Whitebark Pine (*Pinus albicaulis*) is found, and only occasionally at lower elevations in central British Columbia (Bent 1946; Munro 1947; Erskine and Stein 1964). In the northwestern states it breeds as far east as north-central Montana (Figure 1) (Skaar 1975). In autumn and winter individuals or flocks descend to lower elevations, and in certain years disperse many kilometres from the normal range.

Such emigrations of Clark's Nutcrackers have been termed dispersal movements or irruptions,[1] depending on the regularity and number of birds involved (irruption is usually restricted to irregular mass movements). What interested us about eruptive dispersal (the term we prefer for extralimital movements of Clark's Nutcracker) was to determine the ultimate and/or proximate factors causing it. Davis and Williams (1957, 1964) found a correlation between coniferous seed crops in the Sierra Nevada and extralimital occurrences of Clark's Nutcracker in the United States from 1898 to 1961. Formosov (1933) and Hollyer (1970) similarly correlated eruptions of the boreal Nutcracker (*N. caryocatactes*) of Eurasia with the seed crop of the Siberian Stone Pine (*Pinus cembra*).

[1]Strictly, a movement of birds *out of* their normal range should be termed an "eruption."

Svärdson (1957) suggested that the seed crops of some European conifers are cyclic and cause cyclic eruptions of some seed-eating birds. Bock and Lepthien (1976) found indications that several species of boreal seed-eating birds irrupt synchronously into the United States, often in alternate years, owing to poor coniferous seed crops in northern Canada.

The present review summarizes all recorded extralimital occurrences in Canada, and examines the regularity, synchrony, and possible causative factors of such dispersal movements.

Results

From 1904 to 1976 at least 67 extralimital occurrences of Clark's Nutcracker were recorded in Canada (Table 1). Most (79%) of the records were between 1960 and 1976, reflecting an increase in the number of field-ornithologists in western Canada. The vast majority of observations were near urban centers (Figure 1). Extralimital sightings have been made as far west as the Queen Charlotte Islands, north to southwestern Yukon, and east to northwestern Ontario.

1. Seasonal Timing and Flock Size

The first two Ontario sightings occurred in November 1972 (Goodwin and Rosche 1973). A third bird, that probably overwintered there, was reported in April 1973; such apparent overwintering following dispersal may not be uncommon, since four nutcracker records occurred in the same winter in Minnesota (Green and Janssen 1975) and Alberta (Table 1) following a number of records in November 1972. Thus, the 75% of occurrences and 85% of total indi-

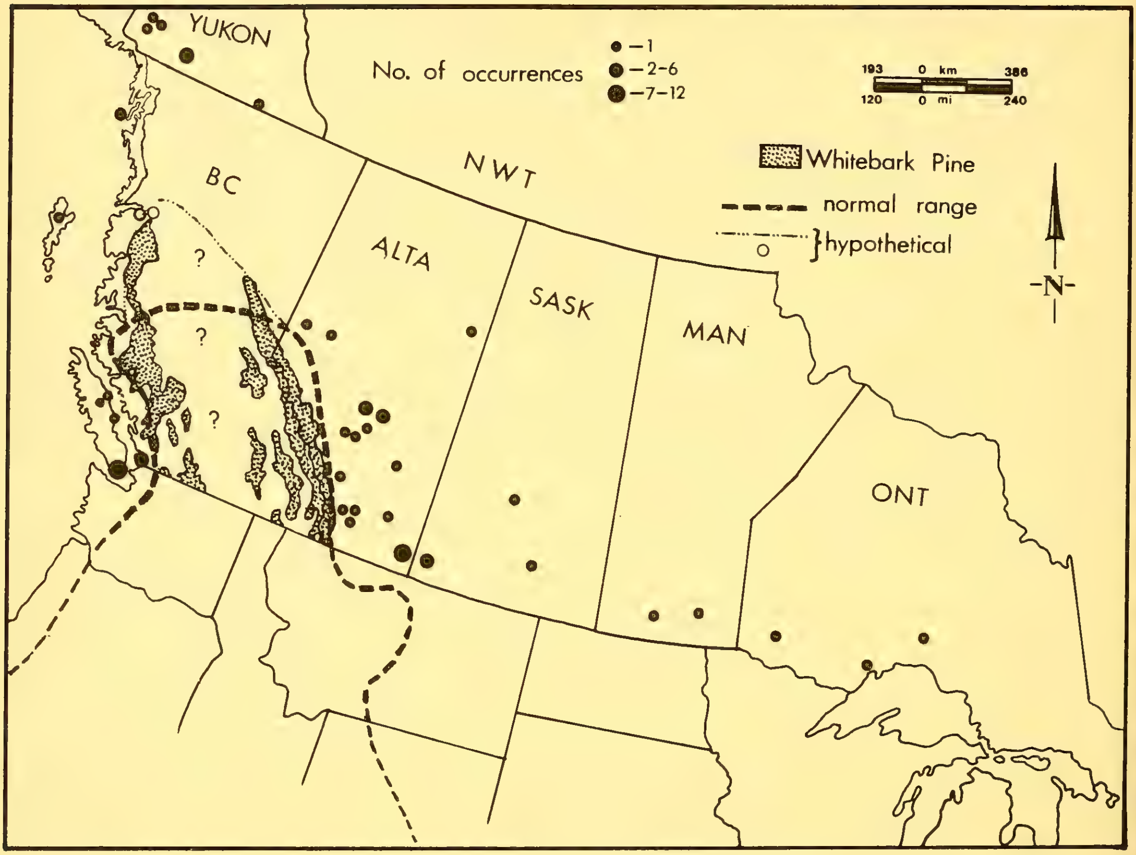

FIGURE 1. Extralimital occurrences of Clark's Nutcracker in Canada to 1976. The differently sized dots indicate the total number of occasions on which nutcrackers (groups as well as single birds) have been recorded at each site. The normal range includes breeding range plus the lower elevations regularly visited in autumn and winter altitudinal migrations (from Godfrey 1966 for Canada and Skaar 1975 for Montana). The "hypothetical range" is based on an unpublished report from A. J. Erskine and two records in Munro (1947). The Canadian distribution of Whitebark Pine is adapted from Hosie (1969). The solid dot in the Alaska Panhandle represents two observations at Sitka in August 1866 and March–April 1933 (Gabrielson and Lincoln 1959).

viduals recorded in August through November probably underestimate the virtual exclusiveness of the fall as the time for eruptive dispersal. For Alberta 70% of the birds were observed in August and September, while in British Columbia 60% were recorded in October and November. The six Yukon observations are inconclusive, ranging from April to August (Table 1), which could indicate local breeding there, but seven of eight records from Alaska range from August to November (Gabrielson and Lincoln 1959; Gibson and Byrd 1973), indicating late summer eruptive dispersal from British Columbia.

The largest monthly mean flock sizes (excluding June because of only one observation then) occurred in August (4.2) and September (5.2) (Figure 2). There was a wide variation in group size (2–30), but the largest flocks of extralimital nutcrackers were recorded in Alberta not far from the normal range (Fisher 1979). Single birds were involved in 70% of the records.

2. Synchrony and Regularity

In the autumn of 1919 extralimital occurrences were reported from Alaska (Murie 1924), British Columbia, Washington (Jewett et al. 1953), California (Bent 1946), Saskatchewan, and North Dakota (Wood 1923). In the autumns of 1960 and 1965 extralimital occurrences were reported from British Columbia and Saskatchewan and from British Columbia and Alberta respectively (Table 1). In the autumn of

TABLE 1—Extralimital occurrences of Clark's Nutcracker in Canada to 1976. First date of the observation is used when an individual was recorded for several days. ( ) spring records with the year of occurrence in parentheses are considered as overwinter survivors from dispersal in the previous autumn

Year	Date	No.	Location	Source
			ONTARIO	
1972	Nov. 9	1	Paipoonge Township	Goodwin and Rosche 1973
1972	Nov. 14	2	Aubrey Township	Goodwin and Rosche 1973
(1973)	Apr. 18	1	Dryden	James 1976
			MANITOBA	
1910	Sept.	1	Margaret (specimen)	Groh 1910
1916	?	1	Winnipeg (specimen)	Godfrey 1966*
			SASKATCHEWAN	
1919	Sept. 19	1**	Ravenscrag/Cypress Hills	Mitchell 1924
1925	Sept.	1	Ravenscrag/Cypress Hills	Potter 1943
1960	Aug. 18	1	Ravenscrag/Cypress Hills	Folker 1961
1963	Oct. 8	1	Ravenscrag/Cypress Hills	Sealy 1971
1968	Mar. 24	1	Moose Jaw	Green 1969
1972	Nov. 18	1	Saskatoon	Shadick 1973
			ALBERTA	
?	Details		Porcupine Hills	Salt and Wilk 1966
?	unavailable		Beaverlodge and Belvedere	Salt and Salt 1976
1965	Aug. 4	1	Stettler	Sadler and Myres 1976
1965	Sept. 26	3	Morley	Sadler and Myres 1976
1966	May 29	1	Rocky Mountain House	Sadler and Myres 1976
1966	Aug.	few	Elkwater, Cypress Hills	A. Fisher, pers. comm.
1968	Dec.	1	Edmonton	Lister 1973
1969	Aug.	1	Brooks	Bayer and Lang 1973
1972	Nov. 12	1	Edmonton	Lister 1973
1972	Nov. 12	1	Carvell Corner	Lister 1973
1972	Nov. 15	1	Ft. McMurray	Lister 1973
1972	Nov. 16	1	Grande Prairie	Lister 1973
1972	Nov. 17	1	32 km SW of Edmonton	Lister 1973
1972	Nov. 17	1	Glenevis	Lister 1973
1972	Nov. 22	1	Pigeon Lake	W. R. Salt, pers. comm.
1972	Nov. 24	1	Lake Wabamun	Lister 1973
(1973)	Feb. 4	2	Leslieville	Lister 1973
(1973)	Mar. 3	1	Edmonton	Lister 1973
(1973)	Mar. 11	1	Edmonton	Animal Record Cards
1973	Nov. 13	1	Edmonton	Animal Record Cards
1974	Dec. 1	1	Winterburn	Animal Record Cards
1976	Aug. 18	1	Elkwater, Cypress Hills	D. Leriger, pers. comm.
1976	Aug. 21	4	Elkwater, Cypress Hills	D. Leriger, pers. comm.
1976	Aug. 25	30	Elkwater, Cypress Hills	D. Leriger, pers. comm.
1976	Aug. 27	2	Elkwater, Cypress Hills	D. Leriger, pers. comm.
1976	Aug. 28	5	Elkwater, Cypress Hills	D. Leriger, pers. comm.
1976	Sept. 4	2	Elkwater, Cypress Hills	D. Leriger, pers. comm.
1976	Sept. 25	30+	Claresholm, Porcupine Hills	Butot 1977
1976	Nov. 9	20	Claresholm, Porcupine Hills	Butot 1977
			BRITISH COLUMBIA	
1904	Feb. 18	1	Comox, V.I.	Brooks and Swarth 1925
1919	?	several	Graham Island, Q.C.I.	Brooks and Swarth 1925
1919	Nov. 1	1	Duncan, V.I.	Munro and Cowan 1947
1931	Nov. 1	1	Chemainus, V.I.	Munro and Cowan 1947
1935	June 19	1	Forbidden Plateau, V.I.	Laing 1942
1935	Nov. 5	several	Campbell R. area, V.I.	Laing 1942
1960	?	?	Sidney, V.I.	Davidson 1966
1965	Sept. 23	2	Metchosin, V.I.	Davidson 1966
1971	June 17	5	Haney area	Campbell et al. 1972
1971	Sept. 13	2	Mount Prevost, V.I.	Tatum 1972

TABLE 1 (continued)

Year	Date	No.	Location	Source
1972	Oct.	1	Duncan, V.I.	Tatum 1973
1972	Oct. 13	1	Mount Finlayson, V.I.	Tatum 1973
1972	Oct. 14	3	Mount Prevost, V.I.	Tatum 1973
1972	Oct. 29	1	Grouse Mountain	Campbell et al. 1974
1972	Nov. 5	2	Greater Victoria, V.I.	Tatum 1973
1972	Nov. 10	1	Pitt Meadows	Campbell et al. 1974
1972	Nov. 12	1	North Vancouver	Campbell et al. 1974
1974	Aug. 13	1	Victoria, V.I.	Crowell and Nehls 1975
1975	Oct.	1	Vancouver	Crowell and Nehls 1976
1975	Oct. 18	1	Victoria, V.I.	Williams 1975
1975	Dec. 20	1	Vancouver	Heilbrun 1976
			YUKON***	
1912	?	1	Robinson	Rand 1946
1943	Aug. 21	1	Rancheria River	Rand 1946
1949	Aug. 21	1	Robinson	Godfrey 1951
1970	May 3	1	Sheep Mountain	Hoefs 1973
1971	Apr. 30	1	Sheep Mountain	Hoefs 1973
1975	July 10	1	Goatherd Mountain	Neily 1976

*Supplemented by V. Humphreys, personal communication.
**S. Pearse saw several birds that year in the area.
***Status in the Yukon unknown.

1969, when only one nutcracker was reported outside its normal range in Canada (in Alberta), several occurred both east and west of the mountains in the northern United States, with some as far east as Minnesota (Bagg 1970). In 1972 a more widespread movement of nutcrackers occurred in Canada, Alaska (Gibson and Byrd 1973), and several other states (Able 1973). In November 1972 five records in Minnesota (Green and Janssen 1975) and two in Ontario were all along the same SW–NE line. In the autumn of 1976 extralimital occurrences were restricted to southern Alberta (Fisher 1979).

In Figure 3 synchrony of extralimital occurrences in different provinces is illustrated from 1960 to 1976. Peak numbers of extralimital observations seem to recur every 3–4 yr in British Columbia and Alberta.

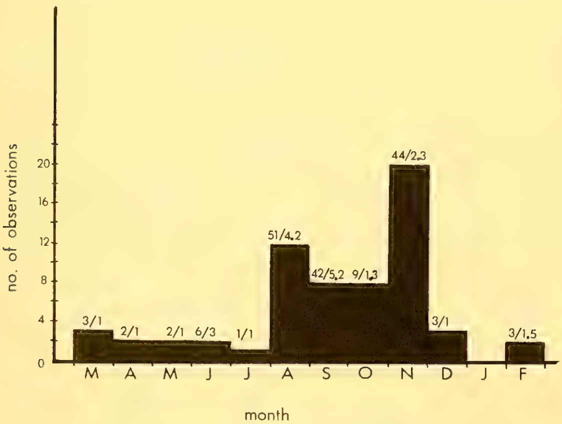

FIGURE 2. Monthly distribution of extralimital occurrences of Clark's Nutcracker in Canada between 1904 and 1976. The number to the left of the diagonal line above the columns is the total number of birds and the number to the right of the diagonal line is the mean flock size.

3. Weather at the Time of Extralimital Occurrences

For 1960 to 1976, weather charts for the day of, or a few days prior to, extralimital occurrences were examined for correlations of weather with dispersal eastwards from the Rocky Mountains. Eight of 10 such movements occurred in conjunction with weather disturbances; the typical pattern was a Pacific low pressure system moving eastward across the mountains, often associated with a cold front and precipitation (in the form of snow, rain, or freezing rain) with generally westerly winds. Two examples are described.

a) November 1972 was exceptionally stormy (Anonymous 1973). From 8 to 10 November, a large low passed over the entire Pacific northwest and brought freezing rain and WSW winds to the Rocky Mountains (Figure 4). Following this, several nutcrackers were reported in the Vancouver and Edmonton areas, as well as the first two Ontario records.

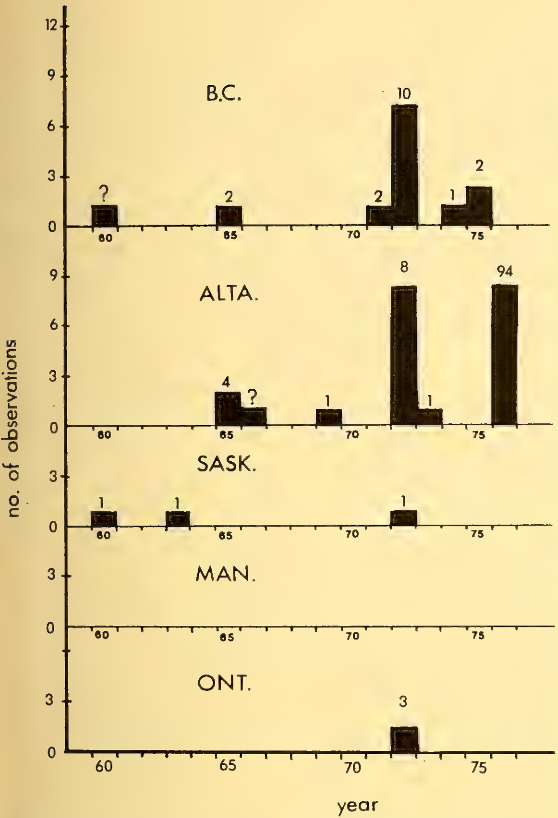

FIGURE 3. Annual distribution of extralimital occurrences of Clark's Nutcracker from August to November only (1960–1976) for each province, showing certain synchronies and regularities between provinces (see text). The number above each column refers to the number of individuals.

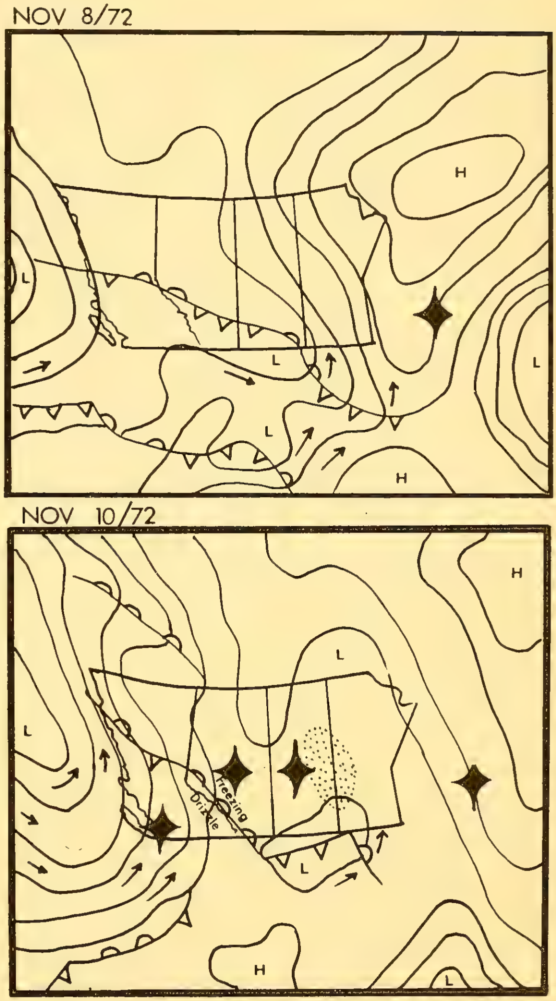

FIGURE 4. (Top). Weather chart showing the position of low pressure systems one day prior to the first extralimital occurrence of a Clark's Nutcracker (four-point star) in Ontario on 9 November 1972. (Bottom). Weather chart for the day of the first two extralimital occurrences of nutcrackers near Vancouver (British Columbia), just prior to several occurrences in central Alberta and the second extralimital occurrence in Ontario, on 14 November 1972. Stippling indicates precipitation. Four-point stars indicate one or more extralimital occurrences of Clark's Nutcracker.

b) In 1976 the western prairie regions had a wet August with subnormal temperatures. Low pressure systems with thunderstorms and showers passed across southern Alberta and northern Montana on 16, 23, and 25 August. At various times during this period winds were from the southwest (from Montana) ahead of southward-moving cold fronts. During this period flocks of nutcrackers were reported in the Cypress Hills, Alberta (Fisher 1979) (Table 1).

Discussion

In studying bird dispersal over vast regions, records of amateur field-naturalists are invaluable. Because Clark's Nutcrackers are conspicuous and because the observations analyzed here are only from locations outside the normal range of the species, the annual number of observations provides a fairly reliable index to the distribution and magnitude of dispersal movements. The number of reports from the Edmonton area in November of 1972 was probably increased by newspaper publicity (R. Lister, personal communication).

Causes of Eruptive Dispersal

The precise factors that cause dispersal in irruptive species are poorly understood (Gadgil 1971). Several studies on Clark's Nutcracker have been done in the United States, but none previously in Canada. Here we relate American evidence to the data available in Canada:

1. *Diet*

Vander Wall and Balda (1977) and Tomback (1978) have shown that Clark's Nutcracker has coevolved with large-seeded pines (e.g., piñon pines and Whitebark Pine) and depends on them as major food sources. In Alberta nutcrackers feed heavily on seeds of Limber Pine (*Pinus flexilis*) and Whitebark Pine (R. Hamilton, Alberta Forest Service, Blairmore, personal communication), and to a lesser extent on Douglas-fir (*Pseudotsuga menziesii*) (B. Frederick, Waterton Lakes National Park, personal communication). Whitebark Pine is presumably the most important food of Clark's Nutcracker in Canada and the ranges of these species are fairly similar (Figure 1).

2. *Caching behavior and seed crop failure*

In the United States, caching of conifer seeds by nutcrackers has been well documented (Turcek and Kelso 1968). Clark's Nutcracker breeds in late winter, and pine seeds cached in the previous year are fed to the young at a time when no other high-energy food is as readily available (Tomback 1978). Caching begins in August and September when Whitebark Pine seeds begin to ripen (Tomback 1978). Vander Wall and Balda (1977) stated that nutcrackers may fly up to 22 km to storage slopes that would be free of snow when the seeds are needed to feed the young.

Davis and Williams (1957) established that in California there is a pattern of two years of good seed crops on all conifers followed by a failure in the third year. Tomback (1978) found that in California the failure of the seed crop of Whitebark Pine in late summer forced birds to feed on Jeffrey Pine (*P. jeffreyi*) at lower elevations; she argued that, regardless of the size of the nutcracker population, if the Jeffrey Pine seed crop also failed in the same year, a major dispersal of nutcrackers to lower elevations might occur. A similar situation in Canada would involve Whitebark Pine, Limber Pine and, at lower elevations, Ponderosa Pine (*P. ponderosa*).

A seed crop failure, be it an evolutionary adaptation of conifers (Janzen 1971) or a result of cold weather in summer (Hollyer 1970), that thwarts seed-caching behavior patterns is a most likely reason for dispersal in nutcrackers.

3. *The passage of weather systems as a proximate factor*

Many extralimital occurrences of nutcrackers in Alberta and farther east have been coincident with weather disturbances passing across their normal range. In the autumn, such low pressure systems may bring thunderstorms and/or strong westerly winds in August and freezing rain or snow from mid-September onwards that could induce or aid the dispersal of nutcrackers downwind from the eastern edge of the normal range in the Rocky Mountains (Figure 4).

Early freezing rain and snow storms in autumn are believed to initiate eruptions of Pine Grosbeak (*Pinicola enucleator*) (Able 1974), Clark's Nutcracker (Small 1974), and the Nutcracker of Eurasia (Hollyer 1970). Freezing rain or thick wet snow and strong west winds are not uncommon in southwestern Alberta in autumn. Sadler and Myres (1976) reported three nutcrackers seen at Morley, Alberta, in September 1965 (Table 1) after a severe autumn snow storm in the mountains.

Sealy (1971) believed that strong winds from northwest Montana were the cause of Dippers (*Cinclus mexicanus*) appearing in southwestern Saskatchewan in the autumn of certain years. There was cool wet weather and a series of low pressure systems over Montana from mid- to late August 1976, and the nutcrackers observed in the Cypress Hills then probably came from northern Montana.

To be forced west towards the Pacific coast, nutcrackers would have to move downwind on the north side of a low pressure cell over the interior of British Columbia, Washington, or California. The occurrence of nutcrackers in "upstate" Alaska is almost certainly explained by passive anticlockwise dispersal north and west around the east and north portions of a low in the Gulf of Alaska, under conditions of poor visibility.

4. *The effect of density and social behavior on dispersal movements*

Lack (1954) believed one cause of eruptions is the density of a population that has become greater than the food supply can sustain, e.g., in tits (*Parus* spp.) (Cramp 1963), Bearded Reedlings (*Panurus biarmicus*) (Axell 1966), and Clark's Nutcracker (Davis and Williams 1957). Density of nutcrackers, however, may also have an indirect effect on dispersal movements. Swanberg (1956) found that the caching of seeds and their retrieval enhances territoriality in the Nutcracker of Eurasia. Dominance of territorial adults over juveniles would explain the high proportion of juveniles in irruptions of the Nutcracker of Eurasia (Lack 1954). Ulfstrand (1963) stated that juveniles in most bird populations are the first to move out in times of food scarcity. Similar social dominance relationships in Steller's Jay (*Cyanocitta stelleri*) were important in causing a major dispersal of juveniles in mid-September (Brown 1963).

Social dominance has not been studied in detail in Clark's Nutcracker but Tomback (1978) found juveniles were less efficient at collecting and caching seeds, making them less able to compete with adults, especially when food supplies are limited. This could account for the high proportion of first-year birds in an irruption in Arizona (Westcott 1964).[2] For Canada there is an unfortunate lack of information on the age-sex composition of extralimital nutcrackers. Mewaldt (1958) provides the most detailed information on aging nutcrackers in the field.

The local irruption of flocks of nutcrackers in southern Alberta in the late summer/autumn of 1976 provides some circumstantial evidence that high density may be important. During the Christmas Bird Count in 1975, 204 nutcrackers were reported in the Banff-Canmore region of Alberta (Copland 1976) — the highest count ever recorded in Canada (Anderson 1976) — which may indicate the population had built up to an unusually high density.

5. *Passive dispersal while searching for food?*

We believe that storms during times of food scarcity are important in carrying Clark's Nutcrackers outside their normal range. Our study of the weather maps suggests that nutcrackers have been dispersed east of the normal range during poor visibility associated with autumn storms. The 1968 irruption of the Nutcracker of Eurasia into northwestern Europe has also been linked to unusually cold July and August weather with snowfalls in the source area of northwestern Russia, with easterly winds favoring a westward dispersal (Hollyer 1970). Although large flocks were reported in Finland, Sweden, and Denmark, most of the birds that reached Great Britain were single individuals.

Whitebark Pine cone circlets are at the tips of the branches. The cones at the tops of trees ripen up to a month earlier than those lower down, and are most readily observed from the air (Tomback 1978). It could be advantageous for nutcrackers to soar above the canopy in search of cone-bearing trees, that may be patchily distributed, when food supplies are scarce. We postulate that Clark's Nutcrackers may have evolved such a "high-flying" strategy for food finding, resembling in appearance (though not necessarily in purpose) the "high-flying" reported by Pearson (1975) as occurring in the Bearded Reedling prior to its dispersal from reed beds. Nutcrackers that utilized such a food-searching strategy would be more susceptible to being carried away by winds when storms develop suddenly in the mountains and visibility is quickly reduced.

In Canada, at the northern margin of the species' range, passive dispersal by wind of birds flying above the canopy searching for cones may be a plausible explanation. In the United States, where nutcracker populations are probably denser and where extralimital occurrences more frequently involve flocks of birds, "high-flying" may be an active dispersal mechanism for the population.

6. *Synchrony and regularity of eruptions in relation to seed crops*

Climatic fluctuations may exert a major influence on the widespread geographic synchrony and regularity of extralimital occurrences of Clark's Nutcracker. Climate can influence the periodicity and/or size of the seed crop of several conifers (e.g., Daubenmire 1960; Eis 1973, 1976) on which nutcrackers feed. The summer of 1972 was the driest in 1200 years according to tree-ring data in the western United States, and this preceded the largest continental eruption of Clark's Nutcrackers ever recorded (Able 1973).

Some synchrony of eruptive dispersals of Clark's Nutcrackers has occurred in North America. In some years this was almost restricted to the United States, e.g., 1969 and other years mentioned by Davis and Williams (1957, 1964), sometimes (as far as we know) restricted to Canada (1960, 1965, 1976), and in other years (1919 and 1972) in both the United States and Canada.

Some regularity of extralimital occurrences was evident when observations from August to November were analyzed for each province separately (Figure 3). In Alberta and British Columbia (since 1960) peaks of observations occurred at intervals of 3–4 yr. To our knowledge, data on seed crops of pines important to Clark's Nutcracker (Whitebark Pine, Limber Pine, and Ponderosa Pine) have not been systematically collected in Canada. Whitebark Pine and Limber Pine are said to produce seed crops every two years with a heavy crop every four years (R. Hamilton, personal communication); Harlow and Harrar (1958) mention less regular seed crops for these species, although they state that Ponderosa Pine has large seed crops every three to five years.

Conclusion

From this review we conclude that populations and extralimital occurrences of Clark's Nutcracker in Canada are ultimately affected by the seed crops of Whitebark Pine and/or one or more other large-seed conifers in the western mountains. Cyclic productivity of seed crops of trees has been shown to be an evolutionary strategy to maximize reproduction (Janzen

[2]Davis and Williams (1957) did not find a high proportion of juveniles in irruptions in California.

1971; Ligon 1978) and it is therefore not surprising to find a 3- to 4-yr regularity in the occurrence of eruptive dispersals of nutcrackers.

It is now possible to suggest a simple model explaining eruptive dispersal in Clark's Nutcracker in Canada. In the spring following a peak conifer seed crop that permitted caching of many seeds, an unusually high survival rate may be expected of young nutcrackers fed on those seeds; however, in the following autumn there will be a poor seed crop, and so the unusually large number of immature nutcrackers that has been raised is placed in jeopardy by a food shortage. Thus, eruptions probably occur most often in the lean years *following* those in which the seed crops are heaviest.

In order to understand the occurrence of dispersal movements of Clark's Nutcrackers and other seed-eating birds, much more detailed information must first be systematically collected year-to-year on seed crop production of the less economically important conifers.

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Behavioral Responses of Muskox Herds to Simulation of Cargo Slinging by Helicopter, Northwest Territories

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Miller, Frank L. and Anne Gunn. 1980. Behavioral responses of Muskox herds to simulation of cargo slinging by helicopter, Northwest Territories. Canadian Field-Naturalist 94(1): 52-60.

During a study of helicopter harassment of three different Muskox (*Ovibos moschatus*) herds we flew two sets of overflights with five passes each and one set of six passes in 1976 and 27 sets of overflights with six passes each in 1977 to simulate exposure to cargo slinging operations. The flights were made over two identifiable Muskox herds in 1976 and over three identifiable herds in 1977. We categorized on-going maintenance activity (bedded or foraging) as no response; alerted or walking as a moderate response; and cantering or galloping as an extreme response. In 1977, but not in 1976, there was a trend toward decreasing responsiveness within the series of passes, which indicated short-term habituation by the Muskoxen to the helicopter flying at high altitudes (> 180 m above ground level). There was consistent variation in the levels of responses among the three herds when similarly harassed, that allowed us to characterize one herd as "calm," one "excitable," and one intermediate. Results from repeated simulations of cargo slinging over the three identifiable Muskox herds suggest that Muskoxen in the most "excitable" herd exhibited most long-term habituation. There was no evidence that the exposure of those Muskoxen to the levels of helicopter harassment we used caused any injuries, herd splintering, or range abandonment.

Key Words: Muskoxen, helicopter, behavior, habituation, Northwest Territories, *Ovibos moschatus*.

In the Arctic helicopters are almost invariably associated with industrial development activities, and one frequent use is the ferrying of cargo by slinging it. Such transport often requires repeated flights between two areas, and could result in animals being repeatedly exposed to the potentially harassing effects of helicopter overflights. We were interested in obtaining information on repeated overflights to determine whether the observed behavioral responses indicated that the animals were becoming accustomed to the overflights.

Our study is the first designed to describe the behavioral responses of Muskoxen to simulations of likely activities associated with industrial developments in the Arctic (Miller and Gunn 1979). We reported a statistically significant trend towards a reduction in responses during simulations of repeated load slinging by helicopter (Miller and Gunn 1979). In this paper, we describe the changes in behavioral responses of Muskoxen that we observed during the sets of passes. We use the term 'habituation' to mean, "The process by which responsiveness to innocuous stimuli becomes temporarily or permanently eliminated . . ." (Marler and Hamilton 1967, p. 642). We use 'short-term habituation' to refer to apparent habituation within sets of helicopter overflights and 'long-term habituation' to refer to apparent habituation between sets of helicopter overflights. Our opportunity to observe habituation was strengthened by our ability to recognize consistently three Muskox herds by their characteristic herd composition and affinity to particular drainages and coastal flats. The process of habituation of ungulates to harassing aircraft under field conditions has not been previously described. We also describe relatively similar levels of responses that characterized the Muskoxen of each herd throughout most of the study period.

Geist[1] reported that even low levels of harassment could result in abandonment of an animal's range. Our ability to relocate three identifiable Muskox herds has enabled us to describe here their range use during the periods of harassment in 1976 and 1977.

Methods

We used a Bell-206B "Jet Ranger" turbo-helicopter from 5 July to 15 August 1976 and from 3 June to 25 August 1977 in our simulations of helicopter activities on northeastern Prince of Wales Island (Figure 1). To simulate cargo slinging, a set of five or six passes in 1976 and a set of six passes in 1977 were flown over Muskox herds at relatively slow speeds (about 80 km/h) and at altitudes between 114 and 400 m above ground level (agl). We flew about 8 km past the herd before turning back to fly another pass over the animals. If weather permitted, and the observers had been able to keep sight of the herd, we flew a second set of passes within 2-6 h of the first series.

We made sets of passes when animals were found in areas overlooked from nearby high ground. We

[1]Geist, V. 1975. Harassment of large mammals and birds. Unpublished report to the Berger Commission, University of Calgary, Alberta. 62 pp.

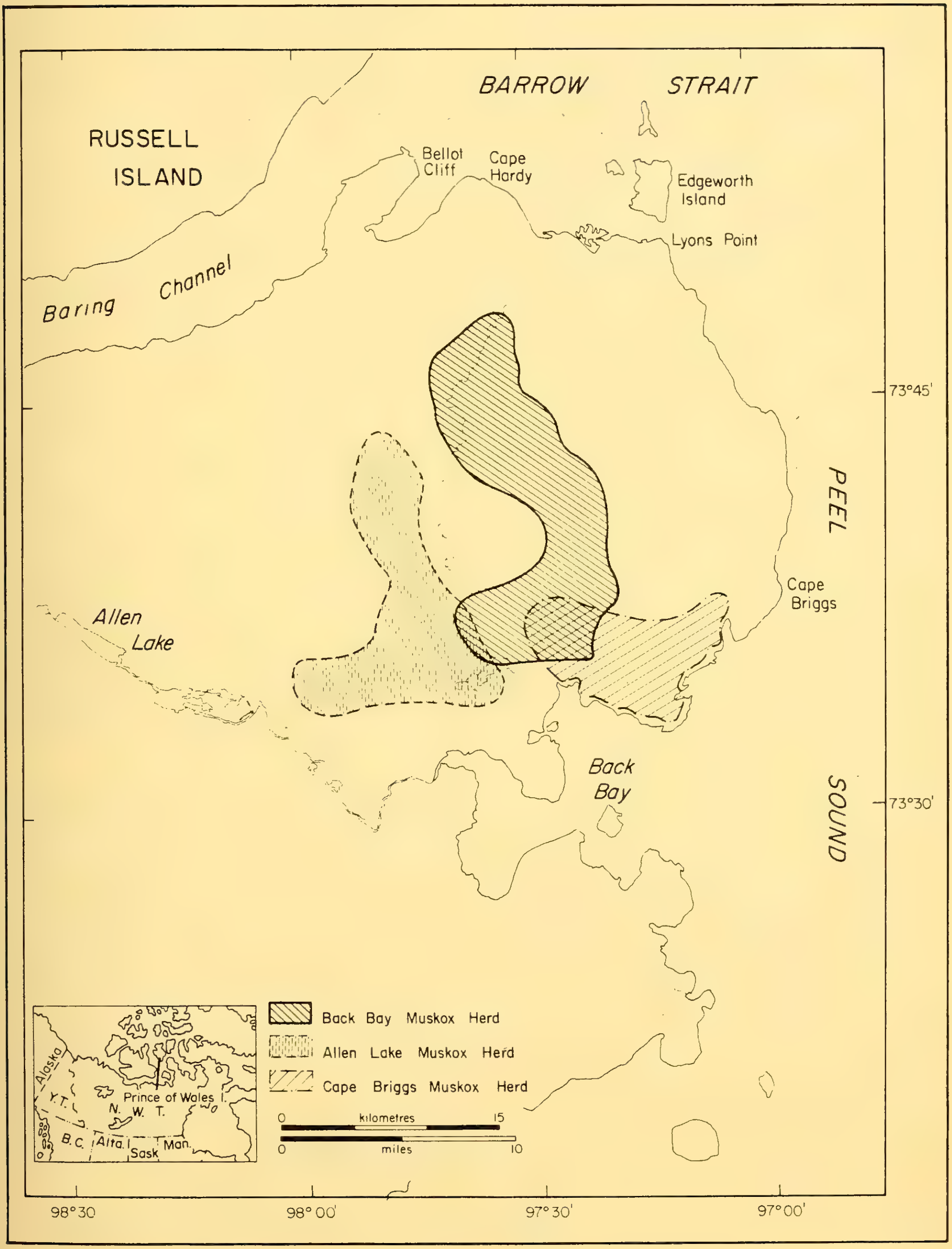

FIGURE 1 — Approximate known summer ranges of the Back Bay, Allen Lake, and Cape Briggs Muskox herds on northeastern Prince of Wales Island, Northwest Territories, 1976–1977.

searched for herds by flying at high altitudes (200–400 m agl) and, on spotting Muskoxen in a suitable location, we attempted to land out of sight 0.4 to 1.6 km away, depending on cover afforded by surrounding terrain. Two observers walked to a prominence and used 15 x 60 zoom spotting scopes and 10 x 40 binoculars to observe the animals. The helicopter attempted to remain out of sight of the herd as it flew away. We started flying passes over the herd within 4 h after observer placement. An observer remained in the helicopter to record the time, altitude, speed, and direction of each pass.

We recorded behavior of individuals continuously during the period of harassment. We identified the response of a Muskox during a helicopter overflight as the maximum behavioral response observed during that flight. We recognized the following categories of overt behavioral responses: (1) bedded, (2) foraging, (3) standing alerted, (4) walking, (5) cantering, and (6) galloping. Our reliance on describing only overt behavioral responses lead us to classify foraging and remaining bedded during helicopter overflights as displaying a lack of response; foraging and bedding are maintenance activities.

We noted the relative position of Muskoxen to each other and whether the locomotary activities of the individuals were directed toward taking up a group defense formation. We recognized alerted Muskoxen by their interruption of foraging or rising from their bed to stand with the head slightly raised, usually looking in the direction of the approaching helicopter. The group defense formation of Muskoxen is the characteristic line, crescent, or circular grouping that herds take up when approached by predators. We recorded whether the Muskoxen were tightly clumped together or had come together in a loose formation.

We have grouped observations of the apparent lack of responses from Muskoxen that remained bedded or foraging during helicopter overflights as 'bedded/foraging' because both acts represent on-going maintenance activities with no additional output of energy. We have also grouped responses from Muskoxen that remained in place but alerted or Muskoxen that walked away from the helicopter overflights as 'alerted/walked' because both responses are moderate and do not place any great additional demands on the animal's expenditure of energy. Lastly, we grouped Muskoxen that cantered or galloped or formed group defense formations during helicopter overflights as 'cantered/galloped/group defense' because those responses may require considerable additional expenditures of energy and tend to be disruptive to on-going maintenance activities and herd socialization.

Chi-square tests of independence applied to two-way contingency tables were used to evaluate distributions of responses statistically. The probabilities obtained using the chi-square test of independence, however, have not been corrected for the possible influence of the herd effect and its associated contagious behavior.

Results

On northeastern Prince of Wales Island, we were able to identify consistently two Muskox herds in 1976. In 1977, we assumed from the sex and age composition and locations that we identified the same two Muskox herds as in 1976 and one additional herd. Our aerial searches in both years revealed no other herds of Muskoxen of similar size or composition on northeastern Prince of Wales Island. In total, we made 30 sets of helicopter flights over those three Muskox herds: seven with the altitudes varying within the set of passes and 23 at constant altitudes for all passes within the set (Table 1). All helicopter flights over the three Muskox herds were at relatively high altitudes in 1977: 69.8% at 300–400 m agl, 25.9% at 200–300 m agl, and only 4.3% at 180–200 m agl (Table 1). Miller and Gunn (1979) have shown that 200 m agl is a statistically significant threshold height for Muskoxen below which extreme level responses occurred proportionately more often than expected. Therefore, no further analysis of responses by altitude has been attempted in this presentation. Possible error in the accuracy of the analysis of responses by 100-m altitude classes is discussed in detail in Miller and Gunn (1979).

Back Bay Muskox Herd

The Back Bay herd ranged on the lowlands around Back Bay, and up and down a northwest-southeast valley leading to the northeast coast of Prince of Wales Island (Figure 1). When first observed on 29 July 1976 the herd included two bulls, seven cows, three juveniles, two yearlings, and four calves. We flew only one set of six passes over the herd on 12 August. The first three passes were at 297 m agl, the fourth at 175 m agl, and the last two at 114 m agl. During each pass the herd responded uniformly by galloping together to take up a tight defense formation. Despite the descending altitudinal pattern of the passes there was a decrease in displacement distance associated with each response during subsequent passes. The distance that the Muskoxen galloped decreased from about 3000 m during the first pass to a few metres during the sixth pass.

When we first observed the herd on 19 June 1977 there were four bulls, nine cows, two juveniles, four yearlings, and eight calves. The similarity of the herd composition and location suggested it was the same herd that we harassed in 1976. One calf was probably 1–2 d old and could be clearly distinguished from the

TABLE 1—Sampling details of repeated simulated cargo-slinging helicopter flights over the Back Bay and Allen Lake Muskox herds, Prince of Wales Island, Northwest Territories, 1977. Each set consisted of six passes

Observation number of each set	Date	Pass number in set	Altitude, m agl
Back Bay herd			
51	19 June	1–5	240
		6	210
57	22	1	360
		2	370
		3	390
		4–6	400
69	23	1–6	270
93	24	1–6	300
94	24	1–6	300
104	25	1–6	300
125	26	1–6	330
198	24 July	1–6	330
226	11 Aug.	1–6	300
231	12	1–6	300
233	12	1–6	300
236	14	1–6	300
247	16	1–6	300
251	16	1–6	300
Allen Lake herd			
6	5 June	1	270
		2, 5	210
		3, 4, 6	180
8	5	1–4	180
		5–6	210
44	18	1–6	330
56	22	1	370
		2–4	390
		5–6	400
70	23	1–6	300
90	24	1–6	270
91	24	1–6	270
102	25	1–6	300
123	26	1–6	270
199	24 July	1–6	330

other calves in the herd. We recorded slight changes in the herd size and sex-age composition during June into August. In August 1977 the onset of the rut caused changes in the numbers of bulls as they tried to join the group and/or were driven out by the herd bull.

We flew seven and six sets of simulated cargo slinging in June and August, respectively, and only one set of simulated cargo slinging in July over the Back Bay herd (Table 1). Difficulties of the observers in maintaining contact with the animals resulted in five incomplete sets of passes with the total loss of 10 passes. During 74 passes we observed 1936 responses of which 68.5% were of Muskoxen that remained bedded or foraging; 12.6% were of Muskoxen that were alerted or walked; and 18.9% were of Muskoxen that cantered or galloped or took part in group defense formations.

Muskoxen of the Back Bay herd exhibited a relative degree of short-term habituation to the helicopter overflights when responses obtained during the first three passes are compared with those of the last three passes within each set of helicopter overflights ($P < 0.005$, Table 2A and Figure 2). Muskoxen tended to canter or gallop or form group defense formations at a relatively greater rate during the first three passes. Subsequently, those Muskoxen remained bedded, or foraging, or alerted, or walked away relatively more often in the last three passes of each set. They showed a relative degree of long-term habituation to the helicopter overflights in 1977 when the distributions of responses to the first seven sets of passes flown (June) are compared to those for the last seven sets of passes (July, August) ($P < 0.005$, Table 2B and Figure 2). Muskoxen that cantered or galloped or took up group defense formations did so at a greater rate during the first seven sets of passes (Figure 2). Muskoxen more often remained in place but alerted, or walked away during the last seven sets of passes (Figure 2). The rates of Muskoxen remaining bedded or foraging did not, however, differ much between the first seven and the last seven sets of passes (Figure 2).

TABLE 2—Distributions of observed responses by Muskoxen of the Back Bay herd to helicopter overflights, Prince of Wales Island, Northwest Territories, 1977. Responses are grouped so as to compare (A) the first three passes of each set with those responses to the last three passes of each set and (B) the first seven sets of passes with those responses to the last seven sets of passes

	Responses			
Pass sequence of each set	Bedded/ foraging	Alerted/ walked	Cantered/ galloped/ group defense	Totals
A. Within sets				
1st–3rd	599	107	280	986
4th–6th	729	136	85	950
Total	1328	243	365	1936
B. Between sets				
1st–7th	697	75	283	1055
8th–14th	631	168	82	881
Total	1328	243	365	1936

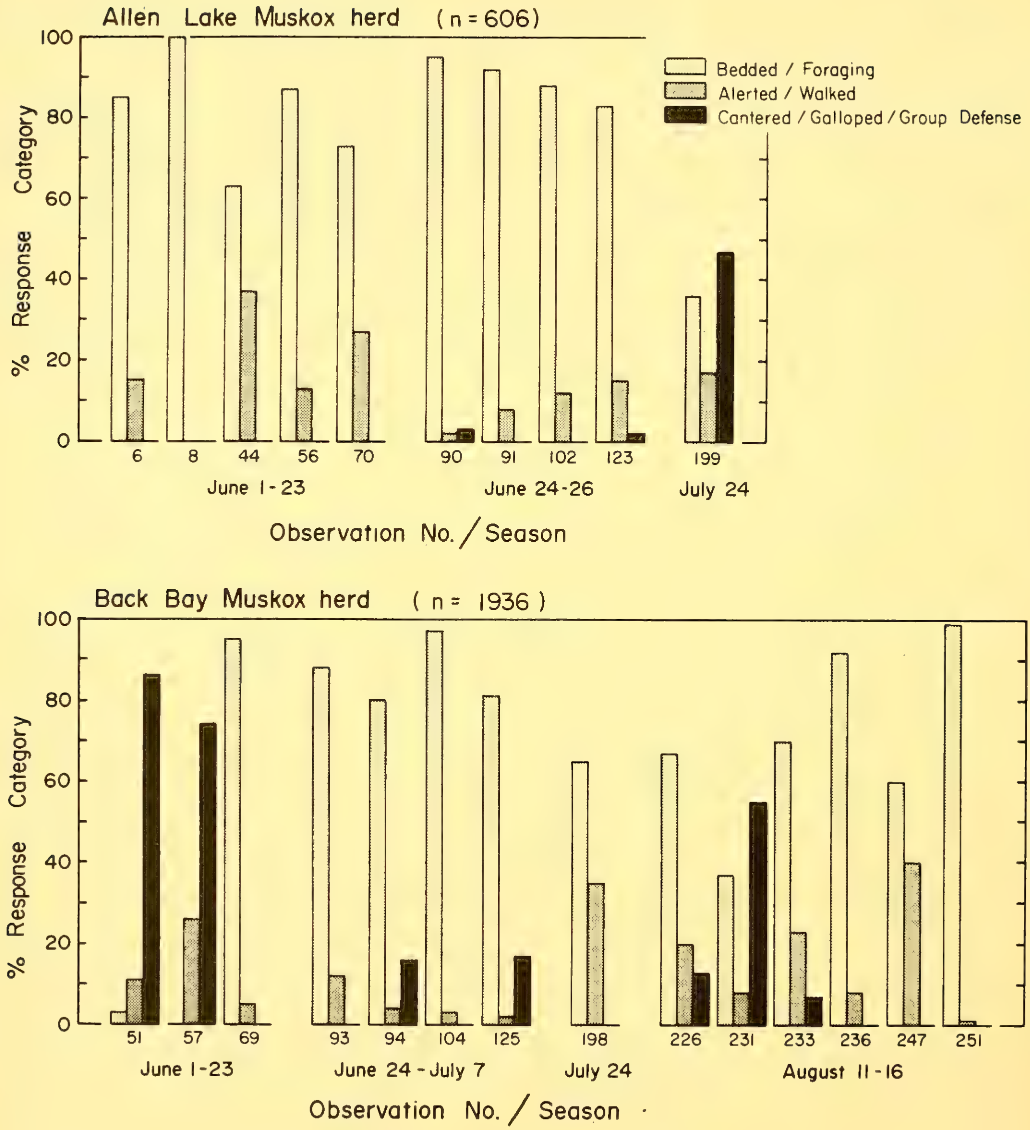

FIGURE 2 — Percentage distributions of response categories obtained from Muskoxen of the Back Bay and Allen Lake herds during simulations of helicopter cargo slinging, Prince of Wales Island, Northwest Territories, 1977.

The Back Bay Muskox herd responded uniformly during 19% of the overflights. Four of the uniform responses involved loose group defense formations during the first two observations in June. Except when the herd all cantered and walked in August, the other eight uniform group responses were at the maintenance activity level involving foraging and bedding. Although there was a trend for the maintenance level uniform responses to occur at the end of several days of simulated slinging, the temporal aspect of the trend was not consistent.

Allen Lake Muskox Herd

We located the Allen Lake herd on 18 July 1976 as they foraged on sedge meadows at the foot of an escarpment (see Figure 1). The herd included two

bulls, two cows, two juveniles, and one calf. We flew two sets of five passes at 305 m agl and 290 m agl on 18 and 19 July 1976, respectively. During the passes we observed 70 responses: 60% of the Muskoxen in each set remained bedded or continued to forage. In the first and second sets, 34.3% and 25.7% remained in place but alerted or walked, 5.7% and 14.3% cantered or galloped or formed group defense formations. Within each set, however, the number of Muskoxen responding decreased as the passes continued: from 11 and 13 Muskoxen in the first three passes to 3 and 1 in the last two passes of each set, respectively.

During June 1977, the herd foraged mainly at the foot of the same escarpment on sedge meadows exposed by the melting snow. In July 1977, lack of helicopter support reduced our ability to locate the herd; also the herd had left the vicinity of the escarpment and moved out onto the coastal area of the head of Back Bay. We relocated the herd at the end of July and harassed them by a set of simulated cargo slingings. In August 1977, the herd moved out onto the lowlands at the south end of the Allen Lake valley. The flat land provided no vantage point for viewing the herd, so we did not carry out any simulated cargo slingings over them.

When we first contacted the Allen Lake herd on 3 June 1977 there were five bulls, two cows, one yearling, and two calves. Two bulls joined the herd on 5 June but had left the herd on 6 June. The herd sex-age composition remained stable until 24 July when one bull had joined the herd but had left when the herd was next seen on 10 August.

We flew 10 sets of simulated slingings over the Allen Lake herd, 9 in June and 1 in July 1977 (Table 1). All the sets of simulated slingings had observations for six passes each except Number 8 when the Muskoxen were out of sight for the first two passes. The 58 passes resulted in 606 responses, of which 79.7% were of Muskoxen that remained bedded or continued to forage; 14.7% were of Muskoxen that alerted or walked; and only 5.6% were of Muskoxen that cantered or galloped or formed group defense formations.

The first two series of passes (Numbers 6 and 8) were in mixed altitude classes (Table 1). The passes of the other eight simulated slingings were at uniform altitudes within a set and most (35) passes were at 201–300 m agl, representing 59.4% of the observed responses. We also flew 18 passes at 301–400 m agl representing 30.7% of the total 606 responses.

Muskoxen from the Allen Lake herd showed a relative degree of short-term habituation to the helicopter overflights when responses obtained during the first three passes are compared with responses to the last three passes within each set ($P < 0.005$, Table 3A and Figure 2). Muskoxen tended to canter or gallop or form group defense formations, or remain alerted or walk at relatively greater rates during the first three passes. Subsequently, those Muskoxen remained bedded or foraging relatively more often during the last three passes. Unlike Muskoxen of the Back Bay herd, the Allen Lake herd did not exhibit any apparent signs of long-term habituation to the helicopter overflights in 1977 (Table 3B). Instead they responded more to helicopter overflights in late season than during the earlier encounters, when responses to the first five sets of passes flown are compared with responses to the last five sets of passes ($P < 0.005$, Table 3B and Figure 2). Muskoxen of the Allen Lake herd responded relatively more often by cantering or galloping or forming group defense formations during the last five sets of passes and less often by being alerted or walking away (Figure 2). The condition is, however, greatly influenced by the last set of passes flown over the herd in July, when the Muskoxen exhibited their strongest responses to helicopter overflights (Figure 2). As with the Back Bay herd, the Allen Lake herd showed sim-

TABLE 3—Distribution of observed responses by Muskoxen of the Allen Lake herd to helicopter overflights, Prince of Wales Island, Northwest Territories, 1977. Responses are grouped so as to compare (A) the first three passes of each set with those responses to the last three passes of each set; (B) the first five sets of passes with those responses to the last five sets of passes; and (C) the first five sets of passes with those responses to only the 6th–9th (10th set deleted) sets of passes

Pass sequence of each set	Responses: Bedded/ foraging	Alerted/ walked	Cantered/ galloped/ group defense	Totals
A. Within sets				
1st–3rd	203	56	32	291
4th–6th	279	24	12	315
Total	482	80	44	606
B. Between sets				
1st–5th	243	49	8	300
6th–10th	239	31	36	306
Total	482	80	44	606
C. Between sets				
1st–5th	243	—[1]	57	300
6th–9th	215	—	25	240
Total	458	—	82	540

[1]Alerted/walked was combined with cantered/galloped/group defense in part C because some of the cells in those two categories were not large enough, with the responses from the 10th set deleted, to permit use of the chi-square test.

ilar rates of Muskoxen remaining bedded or foraging throughout all sets of passes (1–5 vs. 6–10).

If, however, we delete the responses to the last set of passes (Number 199) and compare the distributions of responses in sets 1–5 to responses in sets 6–9, we obtain significant differences, which suggest a relative degree of long-term habituation (Table 3C and Figure 2). We must combine alerted/walked with cantered/galloped/group defense to carry out the statistical test because the cell for sets 6–9 in the latter category is too small (n = 3) for testing. The resultant analysis of the apparent lack of responses (bedded/foraging) to all observed responses indicates that Muskoxen of the Allen Lake herd did become relatively less responsive with time (Table 3C). Proportionately more of them responded to the overflights during sets 1–5 than in sets 6–9 ($P < 0.01$, Table 3C and Figure 2).

Examination of the transcript of the single July observation (Number 199) suggests that rutting behavior influenced the responses, as bulls were head-pushing during the passes. The possible influence of the rut appears to prevent us from clearly identifying long-term habituation by the Allen Lake herd between sets of helicopter overflights. We suggest, from the overt responses, that the Allen Lake herd was a relatively "calm" herd. We tentatively point to the high ratio of bulls to other sex-age classes as a reason for this "calmness." When the overt responsiveness is compared among sex-age classes, bull and yearling percentage contributions to the extreme level were less than those of cows and calves (Miller and Gunn 1979). Bulls and the yearling that remained involved in maintenance activities were 86.7% and 84.5%, compared to 74.1% and 62.9% for cows and calves, respectively.

Cape Briggs Muskox Herd

The third herd that we were able to harass on three occasions was the Cape Briggs herd (Figure 1). We did not harass this herd in 1976, and were able to locate this herd on only 7 different days in 1977, partly because we did not often fly in that area, and also because when the herd had left the narrow coastal plain we were not able to relocate it.

In June and July 1977, we were particularly interested in the Cape Briggs herd because there were no bulls, and a maternal cow acted in the role of the herd bull. In August 1977, two bulls had joined the herd of five cows, two yearlings, and five calves.

On 18 June 1977, we flew the first pass at 240 m agl and five passes at 330 m agl, and on 19 June, six passes at 240 m agl. The 12 passes resulted in 144 responses, and all were of Muskoxen cantering or galloping or taking part in defense formations, except the lead cow which stood alerted outside the group defense formations during five passes, in the manner common to herd bulls.

There was, however, a slight decrease in the responsiveness of the Muskoxen as the passes continued, which was manifested in the slowing down from cantering together to walking together and the change from tight to loose defense formations. The Muskoxen cantered together to form tight defense formations for each of the first three passes. A cow cantered, a yearling galloped, and the others walked together to form a loose group defense formation during the fourth pass. The Muskoxen walked together to form tight and loose defense formations in the fifth and sixth passes, respectively. We returned the following day and observed that the Muskoxen walked together to form tight defense group formations during the first three passes and the sixth pass. The Muskoxen took up loose defense group formations during fourth and fifth passes.

On 2 August 1977, we again flew six passes at 300 m agl over the Cape Briggs herd and the 84 responses were distributed as 53.6% remained bedded or foraging; 22.6% alerted or walked; and 23.8% cantered or galloped or formed group defense formations. The first, fourth, and sixth passes elicited similar responses of the Muskoxen walking together; they either formed a loose defense formation (first and sixth passes) or a tight defense formation (fourth pass) with the herd bull remaining outside the formation. On the second pass, only two cow-calf pairs and the herd bull formed a loose defense group formation; one bull remained bedded and the remaining Muskoxen stood in place, all alerted. During the third pass two cow-calf pairs remained bedded, three cow-calf pairs and the two yearlings foraged, and the two bulls stood alerted. In the fifth pass one bull remained bedded; one cow, three calves, and the two yearlings foraged; the herd bull, four cows, and two calves stood alerted to the helicopter.

There was an apparent decline in responses over the three sets of simulated slingings, which could be attributed to the two bulls joining the herd. Although the last series was during the rut, the two bulls did not head-push during the passes, a behavior that we frequently observed to cause locomotary responses by other individuals. The herd bull, however, was tending a cow with sniffing and attempted mounts during the August observation.

Discussion

Our observations of identified Muskoxen repeatedly harassed over a period of time are unique among published accounts of harassment of large mammals. We have described short-term habituation to the helicopter overhead flights within sets of passes by all three herds. We also detected some long-term habituation by one herd with apparent increases in respon-

siveness with time by the other two herds, seemingly mainly influenced by rutting activities.

The frequency of the sets of passes was unsystematic because of limitations imposed by weather and the location of the herds in areas suitable for observation. Our landings to place and pick up the observers may have influenced the Muskoxen but we could not observe any continuation of responses from the landings as the passes began only when the Muskoxen were bedded or foraging.

Geist (*op. cit.*) identified abandonment of range as a potential effect of harassment but we believe that during the 3 months in 1977 we observed the Back Bay and Allen Lake herds, we did not cause them to leave their normal ranges in that area of northeastern Prince of Wales Island. In May, July, and August 1978 during other Canadian Wildlife Service studies we saw herds of similar size and sex and age composition as the Allen Lake and Back Bay herds that were foraging in the same areas as in 1977 and 1976. Stability of those Muskox herds most likely persists because the low number and density of Muskoxen on northeastern Prince of Wales Island minimizes the disruptive influences of inter-herd encounters.

Our impression is that Muskoxen on Prince of Wales Island are mainly sedentary in summer with a relatively fixed-sized range within which they move according to phenology of the vegetation, drainage conditions, and possibly the size of the herd. Therefore, there is a consensus that Muskoxen are relatively sedentary (Hone 1934; Tener 1965; Gray 1973; Wilkinson and Shank[2]). Wilkinson and Shank (*op. cit.*, pp. 122–136) describe detailed movements of some Muskox herds on Banks Island. Their results show that although Muskoxen remained feeding in relatively small areas for days at a time, they would also move several kilometres to new foraging areas. All the movements that we observed are within the ranges of daily movements these authors described. We do not know the degree of influence of terrain, snow cover, phenology of vegetation, weather, and reproductive cycle phase on movements.

Some of the variation in response levels to similar intensities of harassment that we observed may be the results of previous experience with helicopter overflights. Other factors such as the stability of social order within the herd, recent exposure to other stressful situations such as wolf (*Canis lupus*) attack and individual variation in behavior are possible modifiers of the response levels. There was a distinct difference among the herds of Muskoxen that we had observed on several occasions to the extent that we could label them as (relatively) calm or excitable. Although we observed a waning of response levels within sets of passes (simulated slinging) this apparent habituation held for only one of the three herds between all sets of passes. Unfortunately, we do not know the situations that will develop and maintain habituation. Thomson (1972), Espmark (1972), and Calef et al. (1976) have all suggested the possibility of habituation of *Rangifer* to aircraft, but on even less tangible evidence than we have presented.

Muskoxen have adapted to human presence (and disturbance) in certain situations but we do not understand the processes that lead up to a learned acceptance or tolerance of the disturbance. An understanding of habituation is critical to fostering the compatability of the well-being of Muskox populations with northern development. It is not, however, only the animals that will have to adapt: industry and government will also have to adapt their operating schedules and policies to provide opportunities for the animals to accept the changes in their environments. In particular, we stress that sporadic low-level flights overhead, circling or following the animals, and landings closeby animals with on-foot approaches are extremely detrimental to animals not only in the short term, but in reducing their likelihood of habituation.

[2]Wilkinson, P. F. and C. C. Shank. 1974. The range-relationships of Musk Oxen and Caribou in northern Banks Island in summer 1973; a study in inter-species competition. Unpublished report prepared for Government of the Northwest Territories, Department of Economic Development, Game Management Division, by LGL Ltd. Environmental Research Associates, Edmonton, Alberta. 3 volumes. 749 pp.

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History of Moose in Northern Alaska and Adjacent Regions

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Moose (*Alces alces*) have occurred in northern Alaska since the late 1800s. Before the 1920s most Moose were probably immigrants from more southern latitudes. Breeding populations became established during the 1920s in the eastern portion of the region, and during the 1950s and 1960s in the western portion. Weather, habitat, and predation were probably not limiting factors to Moose in northern Alaska during the late 1800s and early 1900s. Temporary cessation of most hunting in northern Alaska and growth of Moose populations south of the region by 1920 were probably the most important factors promoting dispersal to, and increase in Moose numbers in, northern Alaska.

Key Words: Moose, *Alces alces,* northern Alaska, historical account.

Moose (*Alces alces*) are holarctic in distribution (Rausch 1963), having emigrated from Siberia across the Bering land bridge to unglaciated refugia in Alaska during the early Rancholabrean Age (Illinoian glaciation) (Pèwè and Hopkins 1967). Both the pollen record (Colinvaux 1964) and the boreal nature of mammals dispersing across the Bering land bridge (Repenning 1967) suggest that tundra and open steppe conditions have prevailed in the Bering Strait region since the interglacial interval preceding the Illinoian glaciation. From the high proportion of grazing mammals found in large-mammal fossil communities, Guthrie (1968) concluded that interior Alaska was primarily a grassland during the late Pleistocene. Browsing mammals were very scarce in the fossil record, and Moose comprised less than 1% of remains at most sites.

Peterson (1955) suggested that Moose persisted during late Pleistocene glaciations in major refugia in central Alaska and in several areas in the northern continental United States. During glacial advances Moose habitat in Alaska was probably marginal, and Moose occurred in relatively low numbers. Post-glacial warming trends between 10 000 and 8000 BP (before present) and again between 6000 and 3000 BP, however, resulted in growth and expansion of forests in Alaska (McCulloch 1967), and therefore in favorable habitats for browsers such as Moose. Post-glacial emigration of Moose occurred from the central Alaska refugia into other areas of Alaska and western Canada (Peterson 1955; Kelsall and Telfer 1974).

The purpose of this paper is to review the record of recent dispersal of Moose into northern Alaska and adjacent regions, and to examine factors that may have influenced the distribution and abundance of Moose in this region before 1970.

Study Area

Northern Alaska is considered here as that portion of Alaska from the crest of the Brooks Range north to the Arctic Ocean (Figure 1). The region is divided into three physiographic provinces (Wahrhaftig 1965). The Brooks Range province consists of rugged mountains from 1200–1500 m elevation in the west to 2100–2400 m elevation in the east. Numerous passes 600–1500 m elevation occur through the mountains. The arctic foothills province consists of rolling plateaus and low hills, and ranges in elevation from 1000 m in the south to 200 m in the north. The province is crossed by north-flowing braided rivers originating in the Brooks Range, of which the Colville River is the longest. The arctic coastal plain province is an area of little relief, gradually declining from a maximum of 200 m elevation in the south to sea level in the north. Continuous permafrost results in poor surface drainage and numerous shallow lakes and extensive areas of saturated soil.

Winters are long, cold, and dry and summers are short, cool, and moist throughout most of northern Alaska. The range of mean minimum to maximum temperatures during July, the warmest month, is 1° to 11°C on the coast and 5° to 17°C inland, while during February, the coldest month, these values range from -32° to -16°C along the coast and -37° to -22°C inland. Winter temperatures below -50°C have been recorded at Umiat on the central Colville River. Mean annual precipitation ranges from 12 cm along the coast to 50 cm in the Brooks Range; total snowfall is 50–75 cm along the coast and 200–250 cm in the mountains. Snow accumulates from September to May, except at higher elevations in the Brooks Range where it may persist during most of the year.

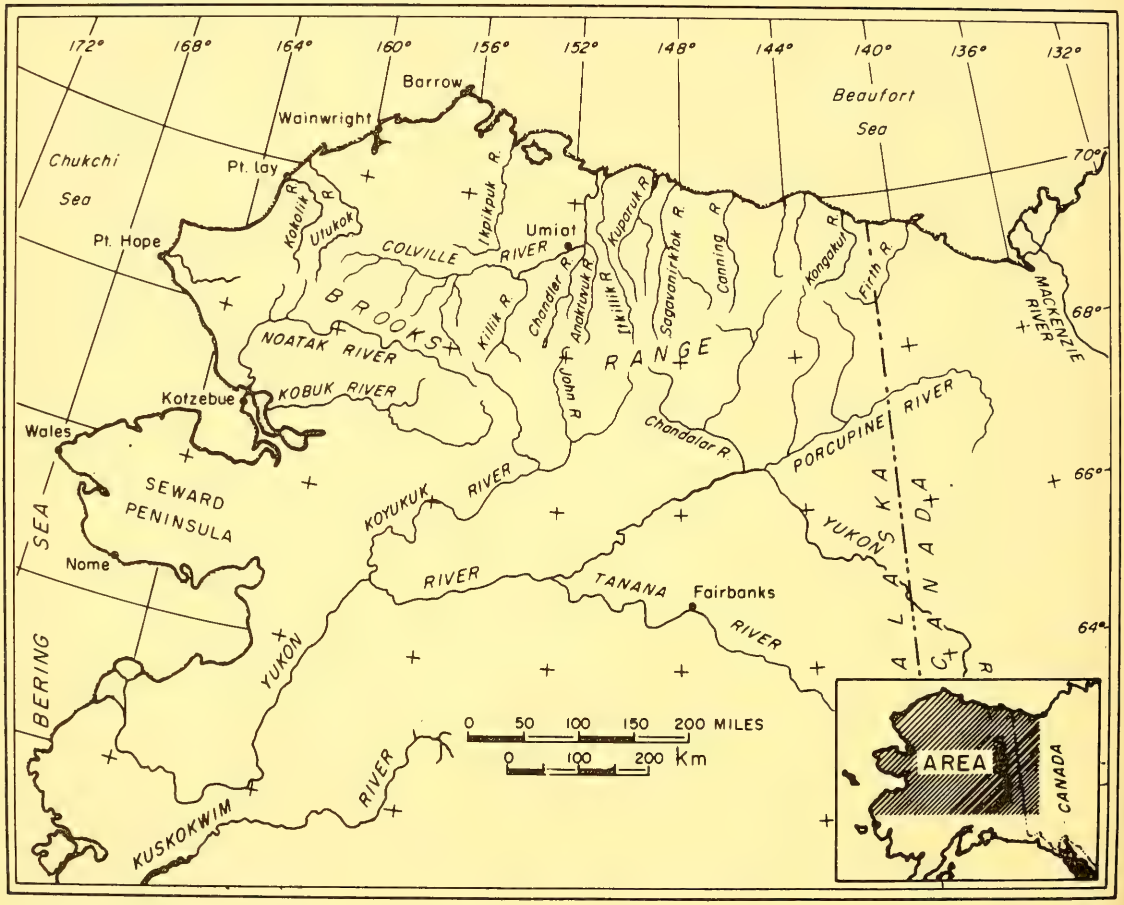

FIGURE 1. Map of northern Alaska. The major study area is that portion of Alaska north of the Brooks Range.

Distribution and Abundance of Moose

I am aware of only one reference to the occurrence of Moose in northern Alaska before 1800. Hall (1973) listed five sites in northern and northwestern Alaska where bones of Moose dated between 980 and 180 BP were found. Hall reasoned that presence of skeletal remains at these sites was due to the natural occurrence of Moose in these areas, and not to trade of Moose meat from more southern areas. I agree with Hall, but add that the paucity of evidence at archaeological sites suggests that Moose were perhaps only occasional immigrants, and that these northern areas were not included in the distributional or breeding range of the species.

Evidence of Moose in northern Alaska and adjacent areas during the 1800s is limited. A Moose was killed in 1825 near the mouth of the Mackenzie River in Canada (Kelsall 1972) and Moose were present in 1861 near Fort Anderson on the Anderson River in Canada (Barry 1961). The Nunamiut Inuit in Alaska did not see Moose north of the Brooks Range before 1870 or 1880 (Gubser 1965); however, between 1880 and 1900 they killed an occasional Moose on the Colville River. Preble (1908) reported that Moose occurred throughout the Mackenzie region as far north as treeline.

The scarcity of Moose in northern Alaska during the 1800s and early 1900s is also apparent from accounts of early explorers in the region. The 1885–1886 Point Barrow expedition of W. L. Howard (no date) did not report seeing Moose on the Kobuk, Noatak, and Colville rivers. Other travelers during the late 1800s saw no evidence of Moose along the Arctic coast or on the Kobuk, Noatak, or Colville rivers (Healy 1887; Nelson and True 1887; Murdock 1898; Stoney 1900). Mendenhall (1902), Smith (1913), and

Giddings (1952), however, reported that a few Moose were known from the upper Kobuk River valley in the 1880s. Leffingwell (1919) did not find Moose in the Canning River region, although he noted that hunting by natives with guns caused Caribou (*Rangifer tarandus*) and Dall Sheep (*Ovis dalli*) numbers to decrease. Murie (1923) quoted an Inuk as saying that a few Moose were found on the north side of the central Brooks Range, although Bailey and Hendee (1926) did not see Moose on an expedition to Wainwright and Point Barrow, even though they travelled inland from Wainwright. Moose were found as far north as the Firth River in 1909 (Nesham 1927). During 1927–1928 and 1930–1935 Moose were rare on the Mackenzie River delta, although in December 1931 a Moose was killed near the Arctic coast a short distance west of the Alaska-Canada boundary (Porsild 1945). Stefansson (1924) reported that Moose were occasionally seen north of timberline along the Mackenzie River and that residents thought that they were both increasing in numbers and expanding their range northward.

Several observations of Moose by Inuit in northern Alaska during the early 1900s are recorded by Bee and Hall (1956). For example, tracks of a Moose were seen in 1924 at Ocean Point near the mouth of the Colville River, some were shot on the Sagavanirktok River in 1929 and near the mouth of the Kuparuk River in 1931. Other Moose were seen near the mouth of the Colville River in 1935, and on the Sagavanirktok River in 1936 and the Killik River in 1945. A Moose was killed at Cape Prince of Wales on the Seward Peninsula in September 1948 (Brooks 1953).

By the early 1950s Moose were common in many areas of northern Alaska. Glaser (1950) counted 34 Moose on the Anaktuvuk River and 109 Moose on the Colville River between Umiat and the mouth of the Killik River in late winter 1950. Several other observations of increasing Moose numbers on the Colville, Chandler, and Anaktuvuk rivers were made between 1950 and 1955 (Bee and Hall 1956; Reed 1956). Observations of abundant Moose in northern Alaska during the 1950s, however, were primarily limited to the eastern half of the region. Bee and Hall (1956) reported record stations for Moose along the Colville River only as far west as Awana River and for rivers east of the Colville River. They also quoted a surveyor as stating that he saw no Moose in 2600 km² of the upper Colville drainage which he surveyed in summer 1950. Glaser (1950) saw no Moose on the Colville River west of the mouth of the Etivluk River in 1950.

By the late 1950s and early 1960s Moose were becoming more abundant in western and northern coastal Alaska. Pruitt (1962, 1966) noted that Moose were observed in northwestern Alaska at Cape Thompson in 1959, Kivalina in 1960, and Point Lay and the upper Colville River at about this time. He also stated that Moose were regular inhabitants of the lower Noatak River. Dean (1964) found that Moose were sparse, but distributed throughout the Noatak River in suitable willow habitat, and he cited a local pilot as saying that the population was increasing in size. Several observations of Moose near Barrow were made between 1958 and 1963 (Chesemore 1968).

Moose also became more abundant in northwestern Canada during the 1950s. Numerous Moose were seen between the head of the Eskimo Lakes and Liverpool Bay, and on the Mackenzie River delta, the upper Yellowknife River, and the Lockhart River (Banfield 1951). Barry (1961) cited an observation of a group of 15 Moose on the delta of the Anderson River in the early 1950s, and reported that he commonly saw Moose on the Anderson River delta during summers 1958, 1959, and 1960.

Beginning in 1970, the Alaska Department of Fish and Game conducted and coordinated Moose surveys throughout northern Alaska. In 1970 and again in 1977, between 1550 and 1700 Moose were observed during extensive aerial surveys conducted in late winter between the Utukok River and the Kongakut River (Coady, files, Alaska Department of Fish and Game, Fairbanks). The greatest density of Moose was found on the middle Colville River and its tributaries, although sizable numbers also occurred along several streams east of the Colville drainage.

Factors Influencing Distribution and Abundance of Moose

Several factors may have affected the early distribution and abundance of Moose in northern Alaska. First, climatic amelioration and its influence on growth of shrubs may have facilitated an increase in Moose abundance, particularly during historic time (Buckley 1967; Leopold and Darling 1953a, b). Glacial advances and retreats occurred in the Brooks Range during the Recent Epoch, with the most recent advance occurring during the early 1800s (Detterman et al. 1958; Porter 1966). Since this recent advance, most glaciers have disappeared or are considerably reduced in size, ground ice in valleys of the Brooks Range has gradually melted, and the snow line has gradually increased in elevation. But the net increase in mean annual temperature in Alaska from the late 1800s to the 1960s has been only about 1° C (Hamilton 1965). Snowfall has probably not changed greatly during this period. Porter (1966) inferred that ablation of glaciers resulted from a rise in mean summer temperature rather than from a decrease in precipitation. Maximum snow depths are usually less than 60 cm at Umiat on the Colville River (University of Alaska 1975). My own observations during April

indicate that snow in winter Moose habitat in northern Alaska is usually 45–60 cm deep and not hard-packed. Therefore, meteorological changes in northern Alaska have probably not significantly favored Moose during this century.

Although moderating temperatures in northern Alaska may have resulted in some growth and expansion of alluvial shrub communities which are important to Moose, suitable habitat for Moose probably existed throughout this century. Smith and Mertie (1930) reported shrub stands with willows (*Salix* spp.) up to 6 m tall and 12 cm diameter on the Killik River and on the middle Colville River during the 1920s. Both Spetzmann (1959) and Bliss and Cantlon (1957) show photographs of the Colville River near Umiat taken in 1947 and 1953, respectively, in which shrub stands appear similar to those existing today. Plant succession on the river alluvium in northern Alaska described by Bliss and Cantlon (1957) requires several decades before "young Feltleaf Willow (*S. alaxensis*) communities" develop into "decadent Feltleaf Willow communities" which were prevalent in 1951 (Churchill 1955). In 1953 Bliss and Cantlon (1957) aged stems on decadent Feltleaf Willows at 46 yr, and in 1975 Coady and Simpson (files, Alaska Department of Fish and Game, Fairbanks) aged stems on decadent Feltleaf Willows and *S. arbusculoides* up to 65 and 85 yr, respectively. Therefore, Feltleaf Willow communities probably existed in northern Alaska in the vicinity of Umiat and elsewhere prior to 1900. Feltleaf Willows are widely used by Moose in northern Alaska today (Mould 1977), and are preferred browse wherever they occur in Alaska (LeResche et al. 1974). Therefore, I hypothesize that lack of suitable habitat was not a factor limiting Moose in northern Alaska during this century.

Predation is another factor which may have influenced Moose abundance in northern Alaska. Nunamiut hunters of Anaktuvuk Pass recall that Gray Wolves (*Canis lupus*) were uncommon in northern Alaska during the early 1900s (Rausch 1951), apparently because Caribou were scarce in the area. Wolves increased in number with the increase in Reindeer (*Rangifer tarandus*) during the 1920s and Caribou during the 1930s and 1940s. Wolf numbers in northern Alaska were sharply reduced during the 1950s because of intensive hunting from aircraft by U.S. Fish and Wildlife Service agents and private individuals. By the late 1960s wolf numbers in northern Alaska were depressed to low levels; since that time they have probably increased slightly, although density in the region is still relatively low.

Although wolves are capable of limiting Moose populations, several observations suggest that this did not occur in northern Alaska. Wolf density was low before 1930 and increased as both Caribou and Moose populations increased in the region (Figure 2). Wolves were usually observed in association with Caribou or Reindeer but not Moose. No wolves were observed near Moose on the Colville River by U.S. Fish and Wildlife Service agents in the 1950s, and their reports of a high calf:adult Moose ratio during late winter suggest that wolves were not preying heavily on Moose. During this period wolves were particularly abundant and Moose population growth was rapid. My observations in northern Alaska indicate that wolves do not prey heavily on Moose as I have seen few wolves or wolf tracks near concentrations of Moose, and few carcasses of Moose killed by wolves; also survival of Moose calves to yearling age is high. Therefore, it does not appear that wolves were a limiting factor to Moose in northern Alaska.

Hunting is another factor which may have influenced Moose populations in northern Alaska. Bands of Nunamiut were periodically widespread throughout most of northern Alaska. Gubser (1965) stated that during the 1800s Nunamiut were composed of four major groups living throughout the Colville River drainage and hunting primarily Caribou. When the Caribou population declined between 1890 and the early 1900s, the Nunamiut population also declined because of disease, starvation, and emigration to the coast (Figure 2). From about 1920 to 1938 no Nunamiut resided in the interior of northern Alaska (Gubser 1965). In 1938 Nunamiut began returning to the Brooks Range, although by 1949 the Nunamiut population in that area consisted of only 65. By the early 1950s most Nunamiut had permanently settled at Anaktuvuk Pass.

Early hunters were clearly able to reduce wildlife populations. Nunamiut thought that the decline of Caribou in northern Alaska during the late 1800s and early 1900s resulted, at least in part, from their own excessive hunting (Gubser 1965). Hunting by Inuit and Caucasians along the coast to supply whaling crews further contributed to the decline of Caribou. Jenness (1957) noted that the Caribou population began to increase by 1915 or 1920, after most Nunamiut emigrated from the Brooks Range. Nunamiut probably temporarily eliminated Dall Sheep from several areas in the Brooks Range during the late 1800s and early 1900s (Campbell 1974), and hunting eliminated Muskox (*Ovibos moschatus*) in northern Alaska during the early 1800s (Hornaday and Brower 1911). Anderson (1924, 1938), Porsild (1945), and Kelsall (1972) presented evidence that hunting locally reduced numbers of Moose in northwest Canada during the late 1800s and early 1900s. In northern Alaska the restricted distribution of Moose habitat along major streams and the open nature of alluvial shrub

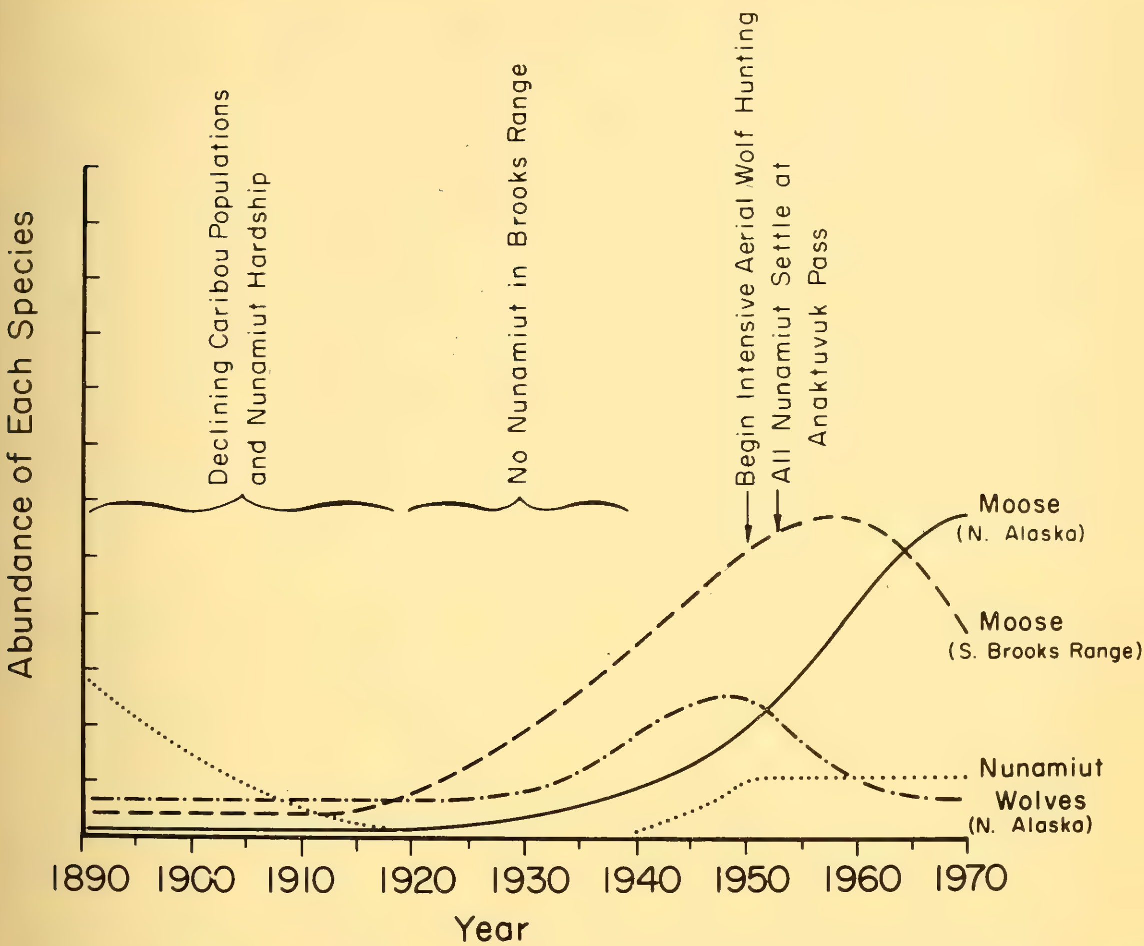

FIGURE 2. Trends in abundance of Moose, Gray Wolves, and Nunamiut north of the Brooks Range and Moose in the southern Brooks Range between 1890 and 1970. Where possible, estimates of population size are given in the text. (The magnitude of change in abundance shown for one population is unrelated to that for other populations.)

communities make Moose conspicuous targets for hunters. Hunting may therefore have precluded population growth in northern Alaska until it was terminated through Nunamiut emigration by 1920.

Hunting has probably been an important factor limiting range expansion and population growth of Moose in other areas of Alaska. On the Seward Peninsula, Moose were extremely scarce before 1950. The number of Moose began to increase in the 1950s, and the population rapidly expanded in both range and size during the 1960s and early 1970s (LeResche et al. 1974). Neither lack of suitable habitat nor excessive predation appeared to be limiting factors; however, hunting by widely dispersed miners may have prevented immigrant Moose from populations east of the region from becoming established. With the decline of mining in the 1940s most human beings deserted interior areas of the peninsula. The resulting decrease in hunting of immigrant Moose probably allowed the species to become established on the Seward Peninsula during the 1950s and 1960s. On the delta region of the Yukon and Kuskokwim rivers a Moose population has yet to become established in spite of favorable habitat and weather conditions and low numbers of predators. An extremely mobile human population occupies inland areas, and the killing of Moose whenever they are encountered has prevented a population from becoming established and growing in this region (Jonrowe 1979).

A final factor which may have influenced Moose abundance in northern Alaska is the status of populations from which emigration could occur. Comments

by early explorers suggest that Moose were scarce on the south side of the Brooks Range during the late 1800s (Allen 1887; Schrader 1900), but increased during the early 1900s (Merrill 1920; Murie 1923; Mertie 1930; Marshall 1933, 1956) (Figure 2). Moose populations south of the Brooks Range were increasing in size during the early 1900s, immediately before and during a time when Moose in northern Alaska were increasing in number. Dispersal by some individuals to new habitat is a mechanism which has favored range expansion and survival of Moose populations (Geist 1971). Northward movement of Moose through passes in the Brooks Range has occurred (Rausch 1951; Gubser 1965), and immigrants from growing populations on the south side of the Brooks Range probably contributed to population growth in northern Alaska beginning in the 1920s. Exchange of Moose between northern Canada and Alaska may also have occurred, but movements along south-north riparian habitats through passes in the Brooks Range seem more likely than east-west movements perpendicular to these habitats.

Discussion and Summary

The limited evidence for the occurrence of Moose in northern Alaska and Canada before 1800 suggests that the breeding range of Moose did not extend into these regions. The few osteological remains of Moose that have been located probably resulted from killing by early hunters of Moose which occasionally immigrated to the area from more southern latitudes. Reports by early explorers as well as comments of native hunters suggest that Moose were seen in northwestern Canada beginning in the early to mid-1800s and in northern Alaska in the late 1800s. It is difficult, however, to determine when Moose became established in these areas on an annual basis, and thereby effectively extended their range north into arctic regions. Very early observations of Moose in northern Alaska and Canada probably represented unusual immigrations of individual animals, and not an actual extension of breeding range.

I hypothesize that both cessation of hunting north of the Brooks Range and growth of Moose populations south of the Brooks Range were the most important factors influencing the dispersal to, and the abundance of Moose in, northern Alaska. Hunting by widely dispersed Nunamiut bands in and north of the Brooks Range during the 1800s probably prevented occasional immigrant Moose from becoming established. Although Moose were generally not a preferred food of the Nunamiut, they were likely killed whenever possible. The first Moose were seen in the Colville drainage between 1880 and 1900 during a period of Nunamiut hardship and food shortage. Movement of all Nunamiut to the coast by 1920 eliminated most hunting of Moose in northern Alaska. This coincided with a time of expanding Moose populations on the south side of the Brooks Range, and therefore probably an increasing number of immigrants to northern Alaska.

Moose apparently became established in eastern and central areas of northern Alaska in the 1920s; this was followed by a gradual extension of their range west along the Colville drainage. When Nunamiut returned to the Brooks Range in the late 1930s and 1940s Moose were few in number and not widely dispersed. Caribou were once again abundant, and therefore the impact of Nunamiut hunting on Moose was probably minimal. At present the Moose population in northern Alaska appears to have slowed its growth and perhaps stabilized in most areas. I estimate that the population now numbers approximately 2000.

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Additions to the Flora of British Columbia

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Nine species of vascular plants are reported to be new to the flora of British Columbia: *Arenaria pusilla, Ceratophyllum echinatum, Cyperus erythrorhizos, Hemicarpha micrantha, Orthocarpus imbricatus, Potamogeton oakesianus, P. strictifolius, Tillaea erecta,* and *Wolffia borealis.* Three of these species, *Arenaria pusilla, Orthocarpus imbricatus,* and *Tillaea erecta* are additions to the flora of Canada. Most of these plants are considered to be native to British Columbia.

Key Words: vascular plants, aquatic plants, geographical distribution, floristics, phytogeography, British Columbia, Pacific Northwest, Canada, new records.

The vastness of British Columbia and poor access to many parts of this province, combined with the great diversity of its vegetation, account for many gaps in our knowledge of the British Columbian flora. Intensive botanical work still yields species not previously reported for the flora of British Columbia (Pojar et al. 1977; Douglas and Ruyle-Douglas 1978).

This paper summarizes the results of studies we conducted in the southern parts of British Columbia during the past few years. It discusses nine species new to the flora of British Columbia, three of which, marked in the text with an asterisk, are new to the flora of Canada.

Voucher specimens of the reported species are deposited in the Herbarium of the British Columbia Provincial Museum, Victoria (V). Duplicates of specimens were distributed to several other herbaria; a full set of specimens of aquatic species has been given to the Water Investigations Branch, British Columbia Ministry of the Environment, Victoria. Abbreviations of cited herbaria follow Holmgren and Kueken (1974); the abbreviation "WIB" is used for the herbarium of the Water Investigations Branch.

Species Accounts

**Arenaria pusilla,* Dwarf Sandwort

This species grows in Arizona and California (Jepson 1925; Munz and Keck 1959), and in Oregon (Peck 1941). In Washington, it has been reported from Klickitat County and southeastern Washington (Hitchcock and Cronquist 1964).

In British Columbia we found only one locality of this species in the Rocky Point area west of Victoria. *Arenaria pusilla* grows here on the flat tops of coastal rock cliffs. It is accompanied by *Orthocarpus pusillus, Plagiobothrys scouleri,* and *Poa confinis.* This locality is close to that of *Tillaea erecta* (see below). Several other southern elements such as *Callitriche marginata, Lotus formosissimus,* and *Microseris bigelovii* occur in its vicinity.

Arenaria pusilla resembles *Stellaria nitens* but has entire petals rather than cleft ones. Sepals of *Arenaria pusilla* have three prominent nerves and lack broad scarious margins in their upper parts. The whole plant has a glaucous tinge, which is especially conspicuous in live specimens.

Collections seen: Rocky Point, Vancouver Island, Church Hill, *A. & O. Ceska 1901,* 7 May 1977 (V).

Ceratophyllum echinatum, Thornwort

Certophyllum echinatum is a species that grows in eastern North America from New Brunswick to Florida and as far west as Ontario, Illinois, and Minnesota (Fernald 1941, 1970).

After we found *C. echinatum* in British Columbia in July 1978, we identified this species in UBC, UVIC, V, and WIB. It occurs sporadically throughout southern Vancouver Island, on the Gulf Islands, in the lower Fraser Valley, and near Pemberton. There is also an interesting specimen from the Alaska Highway.

There are not many collections of the genus *Ceratophyllum* from British Columbia, because the identification of *C. demersum,* the only species so far known here, has not posed any problem. *Ceratophyllum echinatum* grows in rather deep water (2–3 m), is usually anchored, and it is difficult to find fragments washed ashore. Probability of its detection in lakes is thus slim without intensive sampling of the bottom flora. In view of our limited knowledge of its distribution in British Columbia, it may well be that *C. echinatum* is native here. The occurrence in British Columbia of several other species that have eastern North American distributions suggests this possibility. Recent surveys show that species of this distributional type, such as *Sparganium fluctuans, Myriophyllum farwellii* (Ceska and Warrington 1976), *Potamogeton strictifolius* (see below), *Megalodonta beckii,* and

Heteranthera dubia, are more common than previously thought.

Ceratophyllum echinatum is very distinct from *Ceratophyllum demersum* when in fruit. Its fruits are wing-margined with several lateral spines (Figure 1). Vegetative parts are usually finer than those of *Ceratophyllum demersum* and leaves tend to be dissected three times. It is, however, difficult to distinguish sterile plants of *C. echinatum* from finer forms of *C. demersum*. There is a slight difference in the setaceous hairs, which in *C. echinatum* start directly from the leaf margin but in *C. demersum* start from small corniculate teeth (Fassett 1953). Both species have distinctive flavonoid patterns. The problematic specimens can thus be reliably identified by a standard technique (Ceska 1977) employing thin-layer chromatography.

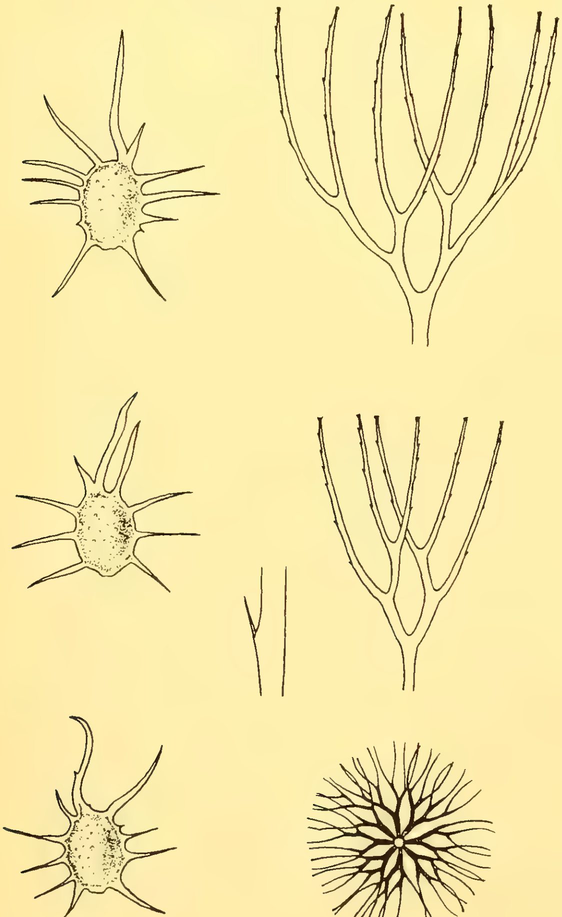

FIGURE 1. *Ceratophyllum echinatum*, fruits, leaves, whorl of leaves, and the detail of leaf margin with setous hair. Drawn by O. Ceska.

Collections seen: South Pender Island, Jennen's Lake, *Ashlee*, 16 June 1961 (V, UBC, UVIC); Alaska Highway, mile 282, *Brayshaw & Barrett*, 21 August 1971 (V); Blinkhorn Lake near Victoria, *Warrington*, 17 September 1971 (UVIC); Shawnigan Lake, southern end, *Warrington*, 27 September 1971 (UVIC); South Pender Island, Greenburn Lake, *Janszen 616*, 11 June 1975 (V); Crofton Lake northeast of Duncan, *Warrington*, 19 June 1975 (WIB); Victoria, Turner's Bog, north of Langford Lake, *A. Ceska 1903*, 4 August 1976 (V); Saltspring Island, Cusheon Lake, *Warrington*, 17 August 1976 (WIB); Sechelt Peninsula, Pender Harbour, Hotel Lake, *Warrington & O. Ceska*, 7 June 1978 (WIB); Nanaimo, Brannen Lake, *A. & O. Ceska 1908*, 20 August 1978 (V); Hope, Devil's Lake, *B. Mitchell 1572*, 1 September 1978 (V) and *A. Ceska & B. Mitchell 1374*, 23 September 1978 (V); Pemberton, One Mile Lake, *A. & O. Ceska 1534*, 11 October 1978 (V); Saltspring Island, Bullock Lake, *Harcombe & McKean*, 12 October 1978 (WIB); Saltspring Island, Ford Lake, *Harcombe & McKean*, 12 October 1978 (WIB); Agassiz, Agassiz Slough, *A. & O. Ceska 1411*, 22 October 1978 (V).

Cyperus erythrorhizos, Red-rooted Cyperus

Cyperus erythrorhizos occurs throughout the United States (Kükenthal 1935–36). In Canada it has been reported in southern Ontario (Kükenthal 1935–36; Boivin 1967a).

This species occurs on the shore of Osoyoos Lake with *Cyperus aristatus*. Although the latter species has been collected by various botanists, *Cyperus erythrorhizos* has not been noticed until recently.

Cyperus erythrorhizos can be distinguished from *C. aristatus* by its adpressed scales which do not have recurved tips, and by the winged rachilla of its spikelets.

Collections seen: Osoyoos, the east shore of Osoyoos Lake, a lagoon at the end of the public beach behind the Sahara Motel, *O. Ceska & Warrington*, 15 August 1977 (V) and *A. & O. Ceska 1113*, 3 August 1978 (V).

Hemicarpha micrantha, Small-flowered Hemicarpha

In North America, this species occurs from California to Florida and as far north as Washington and Ontario (Friedland 1941; Argus and White 1977). It also occurs in tropical America.

In 1978 we collected *H. micrantha* on the shore of Osoyoos Lake in the Okanagan Valley. *Hemicarpha micrantha* grows with several other rare species such as *Centaurium exaltatum*, *Cyperus aristatus*, *C. erythrorhizos*, *Rotala ramosior*, and *Teucrium canadense*.

Previous reports of *H. micrantha* in British Columbia (Szczawinski and Harrison 1973; Taylor and MacBryde 1977) were based on an incorrectly identified specimen of *Isolepis setacea* (cf., Scoggan 1978). This species, introduced from Europe, was collected by Malte in 1921 in the Victoria area (V, CAN) and still occurs there in the Royal Oak area (*O. & A. Ceska, 1907* V).

Hemicarpha micrantha closely resembles *Isolepis setacea* in its habit. It can be recognized by its pitted achenes as opposed to the corrugated ones in the latter species. In addition to its ordinary outer scale, it also has a thin inner scale subtending the flower.

Collections seen: Osoyoos, the east shore of Osoyoos Lake, a lagoon at the end of the public beach behind the Sahara Motel, *A. & O. Ceska 1115,* 3 August 1978 (V).

**Orthocarpus imbricatus,* Mountain Owl-clover

This species occurs from the Klamath and Cascade ranges of northern California to central Oregon. It occurs disjunctly in the Olympic Mountains in Washington, where it was collected at Hurricane Ridge, Mount Angeles, and Marmot Pass (Jones 1936).

In British Columbia we found it on the southern slopes of Little Mount Hooper, north of Cowichan Lake, Vancouver Island. *Orthocarpus imbricatus* forms large stands on dry scree slopes at an elevation of about 1250 m. It is accompanied by several other plants which are rather rare on Vancouver Island (e.g., *Allium crenulatum, Aster paucicapitatus, Saussurea americana, Spiraea pyramidata*).

Orthocarpus imbricatus resembles the lowland species, *O. bracteosus* but has eglandular bracts that are sharply differentiated from the stem leaves (Figure 2).

Collections seen: Lower Mount Hooper (49°00′7″N, 124°27′5″W), *O. & A. Ceska, Pojar & Roemer 1906,* 26 September 1976 (V, CAN, DAO).

FIGURE 2. *Orthocarpus imbricatus.* Photo A. Ceska.

Potamogeton oakesianus, Oakes' Pondweed

Potamogeton oakesianus occurs in eastern North America from Newfoundland to Maine and New Jersey, and as far west as central New York, Michigan, Wisconsin, and western Ontario (Ogden 1943).

We found it at one location in the lower Fraser Valley, north of Mission, where it occurs in a peaty lake. The lake and its shoreline hosts species such as *Potamogeton epihydrus, Utricularia intermedia, Scirpus subterminalis, Potentilla palustris, Dulichium arundinaceum, Hypericum anagalloides,* and *Ledum groenlandicum.* It is most likely, however, that *Potamogeton oakesianus* was introduced with the water-lilies (*Nymphaea* sp.).

Potamogeton oakesianus is closely related to *P. natans* and resembles depauperate individuals of the latter. It differs from *P. natans,* however, in fruit characteristics, stem anatomy, and in the leaves that form on branched stems (Ogden 1943). The stem anatomy of *P. oakesianus* is especially helpful in distinguishing it from the depauperate forms of *P. natans*; the former has interlacunar bundles in only one layer whereas the latter has them in several layers of the stem aerenchyma.

Collections seen: Steelhead, north of Mission, a small private lake on McCombs' Road, *A. & O. Ceska & B. Mitchell 1413,* 24 October 1978 (V).

Potamogeton strictifolius, Pondweed

Potamogeton strictifolius is apparently a trans-American floral element. In Canada it is known from Quebec to the Northwest Territories (Haynes 1974). It is considered to be rare in Alberta (Argus and White 1978) where it occurs only in "a few localities" (Moss

1959). The only collection from the area west of the Continental Divide is that from Utah (Fernald 1932; Haynes 1974; Cronquist et al. 1977).

In British Columbia we found it in the lower Fraser Valley (Kawkawa Lake near Hope) and in the Rocky Mountain Trench (Windermere and Columbia lakes). It occurs with *Heteranthera dubia* in Kawkawa Lake, and with *Megalodonta beckii* in both Windermere and Columbia lakes.

Potamogeton strictifolius is related to *P. friesii* but is distinguished by its acute leaf tips and revolute leaf margins (Voss 1972; Haynes 1974). The plants look like a miniature of *Potamogeton robbinsii.* Their leaves are stiff, deep olive green in color, and often two-ranked. The growth habit of *P. strictifolius* is also similar to that of *P. robbinsii*; the plants grow in dense clumps covering lake bottoms.

Collections seen: Windermere Lake, southern end, *A. & O. Ceska 925,* 13 September 1978 (V); Columbia Lake, northern end, *A. & O. Ceska 958,* 13 September 1978 (V); Hope, Kawkawa Lake, *A. Ceska & B. Mitchell 1372,* 23 September 1978 (V).

**Tillaea erecta,* Erect Pigmy-weed

This species is known from California, Arizona, and southwestern Oregon, and it also occurs in South America in Chile (Britton and Rose 1905; Munz and Keck 1959). It is an annual species that grows in chaparral (McPherson and Muller 1969), vernal pools (Holland and Jain 1977), and on coastal cliffs.

In our area, *T. erecta* was found on the coastal cliffs of Sidney Island and on Rocky Point west of Victoria. We also found *T. erecta* as a species new to the flora of Washington; it was collected on two locations on San Juan Island. In all of these localities *T. erecta* occurs along the coast, at the edge of till deposits over basaltic rocks. All of these sites stay wet in spring because of seeping water.

Tillaea erecta is a diminutive succulent with opposite leaves and tetramerous flowers (Figure 3).

Collections seen: San Juan Island, Washington, northern side of Deadman Bay, *O. & A. Ceska,* 8 April 1977 [new for Washington] (V, WTU); San Juan Island, 7.8 mi [12.5 km] NW of Friday Harbour, west side of Mount Dallas, ca. 8 mi [13 km] S of Deadman's Cove, *Elvander 884,* 13 May 1977 (WTU); Sidney Island, southern end, *O. & A. Ceska & Pojar 1904,* 17 April 1977 (V, CAN, DAO); Rocky Point west of Victoria, seashore between Church Hill and Smyth Head, *O. & A. Ceska 1905,* 4 May 1977 (V).

Wolffia borealis (Engelm.) Landolt, Water-meal

Landolt and Wildi (1977) segregated the northern populations of *Wolffia punctata* as *W. borealis,* and treated *W. papulifera* and southern populations of *W. punctata* conspecific with *W. brasiliensis.*

FIGURE 3. *Tillaea erecta,* habit and flower. Drawn by O. Ceska.

Wolffia borealis occurs in the northeastern United States in Michigan, Wisconsin, Illinois, Iowa, Ohio, and New York, and in the Pacific Northwest in Oregon (Landolt and Wildi 1977). In Canada it occurs in Ontario (Dore 1957; Soper 1962). According to Scoggan (1978), reports of *W. borealis* from Quebec (Soper 1962; Boivin 1967b) are based on misidentification.

In British Columbia we collected *W. borealis* in several eutrophic ponds and sloughs in the lower Fraser Valley and in Duck Lake north of Creston. It grows with *Spirodela polyrhiza* and *Lemna turionifera* and it often forms dense populations which are conspicuous because of their olive green color.

Wolffia borealis can be distinguished from all other British Columbian members of the family Lemnaceae by its oblong-elliptic, rootless fronds.

Collections seen: Chilliwack, "Goose Lake" near MacDonald Park, *O. & A. Ceska & B. Mitchell 1162,* 24 June 1978 (V); Fort Langley, the pond on Sellers Avenue southwest of town, *A. Ceska & B. Mitchell 1305,* 9 July 1978 (V); Mission, the pond on Hatzic Slough north of Hatzic Lake, *A. & O. Ceska, S. & B. Mitchell, 1555,* 15 August 1978 (V) and *Brayshaw 78818,* 24 August 1978 (V); Mission, the ditch along Lougheed Highway at Silverdale, A. & O. Ceska 1556, 15 August 1978 (V); Duck Lake north of Creston, *A. & O. Ceska 742,* 3 September 1978 (V); Agassiz, the pond near Maria Slough, *A. & O. Ceska & B. Mitchell 1679,* October 1978 (V).

Discussion

Three phytogeographic groups of species are represented in our account: (1) species that occur in the western part of North America, mainly in California and Oregon and less commonly in Washington (*Arenaria pusilla, Orthocarpus imbricatus,* and *Tillaea erecta*); (2) species that occur across North America south of the Canadian border, with some of them occurring in Ontario (*Cyperus erythrorhizos* and *Hemicarpha micrantha*); and (3) species that occur mainly in the northern part of North America, and are known especially in its eastern regions (*Ceratophyllum echinatum, Potamogeton strictifolius, P. oakesianus,* and *Wolffia borealis*).

Most of the species dealt with here are considered to be native to British Columbia. It is, however, difficult to draw a conclusion about the status of *Ceratophyllum echinatum. Potamogeton oakesianus* was probably introduced.

We make the following recommendations concerning conservation problems and the direction of further surveys.

1) Most of our additions are aquatic and wetland plants. This group of plants has been neglected in British Columbia and more collecting and field surveys must be done before we can arrive at a comprehensive treatment of these plants.

2) The Rocky Point area, west of Victoria, is of extreme interest floristically. At present this area lies within a National Defence establishment and is restricted to the public. This status is thus ideal for the protection of many plant species that have disappeared from the populated areas of Victoria. If the status of Rocky Point were to change in the future, Church Hill and the shore cliffs northwards to Becher Bay should be preserved.

3) Osoyoos Lake and the surrounding area is the northern-most locality for many plant species that reach British Columbia from the south. Most of these species belong to a group that grows at the seasonally exposed lakeshore, a habitat that is rapidly disappearing because of human activities. The presence of Eurasian Water Milfoil (*Myriophyllum spicatum*) in Osoyoos Lake could prompt chemical treatment of the lake, an undertaking that would further destroy the shoreline plant communities. A detailed study of Osoyoos Lake and its shore is, therefore, very urgently needed. Certain areas of the lakeshore should be protected as an ecological reserve.

Acknowledgments

We thank E. Landolt for identifying *Wolffia borealis* and *Lemna turionifera,* R. R. Haynes for confirming the identification of *Potamogeton strictifolius,* P. D. Warrington for lending us specimens from the Water Investigations Branch collection, H. L. Roemer and J. Pojar for participating in the field trips to Little Mount Hooper and Sidney Island, and the Ecological Reserve Unit for providing transportation for these trips. We also thank G. W. Douglas and Mrs. G. A. Moyer for reading and commenting upon the manuscript and for their editorial assistance. Most of the aquatic and wetland plants reported here were found during the survey contracted to the Ceska Geobotanical Research Company by the Water Investigations Branch, Ministry of Environment, Victoria. The Water Investigations Branch also paid for chromatographic analyses of *Ceratophyllum* specimens.

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Addendum

Since the submission of this paper, botanists of the Water Investigations Branch of Victoria have located *Ceratophyllum echinatum* in the following additional localities: Prior Lake near Victoria, *Warrington & Harcombe,* 23 May 1979; an unnamed pond between Maltby and Prospect Lakes, Victoria, *Warrington & Harcombe,* 30 May 1979; McKenzie Lake near Victoria, *Warrington & Harcombe,* 30 May 1979; Cowichan Lake, Vancouver Island, at the eastern end near the eastern channel, *Warrington & Soar,* 10 July 1979; Millstone Creek Pond near Nanaimo, *Warrington & Harcombe,* 27 August 1979; and Richard Lake near Nanaimo, *Warrington & Harcombe,* 28 August 1979. Voucher specimens are deposited in the Water Investigations Branch herbarium.

We also found a specimen of *Ceratophyllum echinatum* from Manitoba which was misidentified as *C. demersum* (Whiteshell Forest Reserve, shallow water, *Scoggan 8724,* 26 June 1951, CAN). This constitutes the first record of *Ceratophyllum echinatum* in Manitoba.

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Movements of Blackbirds and Starlings in Southwestern Quebec and Eastern Ontario in Relation to Crop Damage and Control

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Weatherhead, Patrick J., Robert G. Clark, J. Roger Bider, and Rodger D. Titman. 1980. Movements of blackbirds and Starlings in southwestern Quebec and eastern Ontario in relation to crop damage and control. Canadian Field-Naturalist 94(1): 75–79.

Band returns for Red-winged Blackbirds, *Agelaius phoeniceus* (49), Starlings, *Sturnus vulgaris* (197), Common Grackles, *Quiscalus quiscula* (318), and Brown-headed Cowbirds, *Molothrus ater* (89) were analyzed to determine seasonal movements of birds encountered in the St. Lawrence Valley of eastern Ontario and southwestern Quebec between 1 March and 15 November. Breeding populations of the four species arrive in the St. Lawrence Valley in April and remain through the crop damage period of early fall. The greatest differences in movement patterns occur in late fall, by which time most Brown-headed Cowbirds and approximately half the Red-winged Blackbirds have left, while most Starlings and Common Grackles remain. These results are discussed in the context of management decisions concerning Red-winged Blackbird damage to corn. The analysis also indicates a need for more information on the size, movement, and role in crop depredation of the blackbird populations north of the St. Lawrence Valley.

Key Words: blackbirds, Starlings, migration, Quebec, Ontario, pest control, agriculture.

Annual corn and small grain losses to blackbirds (Icteridae) in the St. Lawrence Valley are estimated in the millions of dollars (V. E. F. Solman, C. D. F. Miller, and G. W. J. Laidlaw, unpublished report). This region also has the most rapidly growing Red-winged Blackbird (*Agelaius phoeniceus*) population in North America (Dolbeer and Stehn 1979) and it is this species of blackbird that is the most serious agricultural pest (Dyer 1967; Dyer and Ward 1977; Martin 1977). In combination, these two factors have led to increasing demands by the farmers in the St. Lawrence Valley for government action to control the birds. The failure of mechanical and chemical frightening agents to provide consistent protection against blackbirds has resulted in greater pressure for a program of population reduction. Our aim in this paper is to determine whether existing band return data (from both live and dead birds) can be used to answer several fundamental questions relating to blackbird population control, and if so, to gain some insight into the feasibility and possible consequences of such a program.

Outside the breeding season Red-winged Blackbirds are highly gregarious, roosting communally at night with conspecifics and often with large numbers of Common Grackles (*Quiscalus quiscula*), Brown-headed Cowbirds (*Molothrus ater*), and Starlings (*Sturnus vulgaris*). It is this concentration in early fall that produces the agricultural problems associated with roosting blackbirds (Wiens and Johnston 1977); but the birds are most accessible to control techniques when concentrated in roosts of this nature. It is necessary to know at what time(s) of the year the birds using local roosts could be responsible for crop damage in that area in order that any reduction in population at those roosts takes place at the appropriate time. Secondly, one must know which populations of the other species of birds in the roost would be affected by reduction at any particular time in order to anticipate the impact of their removal.

The analysis of band return data to answer the questions posed above does, to some extent, overlap existing studies of continental migration patterns in Red-winged Blackbirds (Dolbeer 1978) and Common Grackles (B. Meanley, unpublished report). Our analysis, however, includes several time-period comparisons relevant to roost population reduction that were not included in those studies. As well, migration patterns are considered relative to a particular agricultural zone rather than on a provincial or broader regional basis, as this is the level at which a control program is most likely to be implemented. The agricultural zone considered in this paper is the St. Lawrence Valley of Quebec and eastern Ontario (Figure 1). The boundaries were chosen to encompass the principal corn-growing area of Quebec and that part of eastern Ontario that might be affected by control efforts in Quebec.

Methods

Recovery listings for birds banded in the study region and for birds banded elsewhere and recovered in this region for the four species in question were obtained from the Canadian Wildlife Service. The listings were limited to birds for which both the banding and recovery dates fell between 1 March and 15

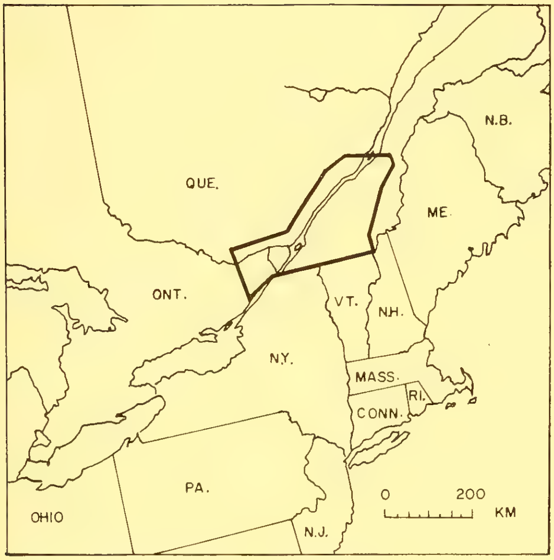

FIGURE 1. Map to show the study region.

November, as the aim of this paper was only to examine movements of birds during the time that control measures within the study region might be carried out. Five periods were designated based on local migration and breeding dates:

1) early spring (1–31 March) — first arrivals of blackbirds;

2) late spring (1–30 April) — birds present in large numbers but not yet breeding;

3) summer (1 May – 15 July) — breeding season;

4) early fall (16 July – 30 September) — fall roosting begins, crop damage occurs;

5) late fall (1 October – 15 November) — roosting continues through this period.

All returns were grouped according to the time periods in which the banding and return (both considered as encounters and thus not differentiated) occurred. These were further separated based upon whether the bird was within the study region for both encounters (local-local), within the study region for the first but not the second encounter (local-not local), or the reverse of the latter (not local-local). This produced 10 pairs of time periods with three categories of encounters in each (see Table 1). Birds encountered twice in the same time period were excluded from the analysis.

Results

The tendencies shown by grouping the data by time periods and locations (i.e., local or not local) of encounters (Table 1), and the percentage of total encounters within a time period that were not local (Figure 2) are summarized below:

Early spring–late spring

Banding and return combinations between these two periods were sparse but in general indicated that although some local late spring birds of all species had arrived by early spring, the majority remained to the south.

Spring–summer

The early spring–summer and the late spring–summer groupings showed that for all four species the majority of birds that bred locally did not arrive until late spring. But there were some individuals of all four species that were present locally in early or late spring and went elsewhere to breed, or that were present during the breeding season but arrived after April.

Summer–fall

In the early fall most of the birds present in the study area appeared to be from local breeding populations, although there were differences of degree between species. Notably, more than 20% of local breeding Brown-headed Cowbirds had left the study region by the end of September. During the late fall period, substantial differences between species occurred. Nearly all Brown-headed Cowbirds present during the breeding season had left while the opposite was true of Starlings. Approximately half of the Red-winged Blackbirds and two thirds of the Common Grackle summer populations remained locally into the late fall.

Spring–fall

These data were particularly sparse and could be used only to check whether they reflected trends already discerned from spring–summer and summer–fall data. The Red-winged Blackbird encounters were too few to discuss. The Starling data indicated that many local birds did not return until late spring although they persisted well into the fall. The same was true of Common Grackles although fewer birds remained in late fall. The Brown-headed Cowbird data again showed a late spring arrival and an early fall departure.

Early fall–late fall

Encounters in these two periods were also very sparse, existing only for Common Grackles and Starlings. These supported the trend mentioned previously in that birds present in early fall tended to remain into the late fall period.

Non–local encounters

The locations of all non-local encounters from Table 1 are presented by species and time period in Table 2. Without considering banding and recovery effort in each area, these data cannot be taken as a quantification of migration patterns but only as an

TABLE 1—Percent encounters by location** of blackbirds and Starlings banded and recovered between 1 March and 15 November, with at least one of these encounters in southwestern Quebec – eastern Ontario. Individuals encountered twice within a seasonal period are not included

Seasonal periods*	Red-winged Blackbird No.	Local – local	Local – not local	Not local – local	Starling No.	Local – local	Local – not local	Not local – local
Early spring – late spring	1	100	0	0	13	23	0	77
Early spring – summer	3	0	0	100	73	40	3	57
Late spring – summer	20	85	10	5	58	91	2	7
Summer – early fall	18	100	0	0	13	92	0	8
Summer – late fall	5	20	60	20	10	80	20	0
Early spring – early fall	0	—	—	—	5	20	0	80
Early spring – late fall	1	100	0	0	14	36	7	57
Late spring – early fall	1	0	0	100	5	60	40	0
Late spring – late fall	0	—	—	—	5	80	20	0
Early fall – late fall	0	—	—	—	1	100	—	—

Seasonal periods*	Common Grackle No.	Local – local	Local – not local	Not local – local	Brown-headed Cowbird No.	Local – local	Local – not local	Not local – local
Early spring – late spring	7	0	14	86	5	0	0	100
Early spring – summer	26	19	4	77	14	0	7	93
Late spring – summer	122	95	1	4	37	86	3	11
Summer – early fall	104	93	1	6	5	80	20	0
Summer – late fall	10	90	10	0	13	15	85	0
Early spring – early fall	11	9	0	91	4	0	0	100
Early spring – late fall	1	0	0	100	1	0	0	100
Late spring – early fall	23	87	0	13	4	25	50	25
Late spring – late fall	4	25	75	0	6	0	100	0
Early fall – late fall	10	80	20	0	0	—	—	—

*Early spring (1–31 March), late spring (1–30 April), summer (1 May – 15 July), early fall (16 July – 30 September), late fall (1 October – 15 November).

**The first and second location in a column heading refer respectively to the first and second seasonal periods in the row heading.

indication of where birds encountered in the study region between 1 March and 15 November were also encountered non-locally during that same period. Comprehensive analyses of continental migration patterns have been done for Red-winged Blackbirds (Dolbeer 1978) and Common Grackles (B. Meanley, unpublished report).

Discussion

Before addressing the questions posed earlier, it is necessary to consider the sources of bias inherent in banding data. The existence of several banding stations in the study region is likely to inflate local recaptures, as discussed by Fankhauser (1968). Also, the huge discrepancy in human population density between the areas north and south of this region, and between their concomitant banding and recovery efforts, would be expected to cause an over-representation of birds banded and recovered to the south. The combined effect of these biases would be that birds moving through this area on their way to and from areas to the north would be under-represented, even if they comprised an important component of local spring and fall populations.

Dyer and Ward (1977) considered the dietary overlap between Red-winged Blackbirds, Common Grackles, and Brown-headed Cowbirds to be sufficient to warrant concern should efforts to control redwings inadvertently release the other species from competition, allowing them to become serious pests. Similarly, Red-winged Blackbird control efforts that were deleterious to Common Grackles, Brown-headed Cowbirds, or Starlings could have undesirable repercussions if the ecological interactions of any of these species had a positive net value. A major research undertaking would be needed to determine the ecological relationships among all four species during each season. The banding data allow some insight into which relationships may be of greatest importance to management planning.

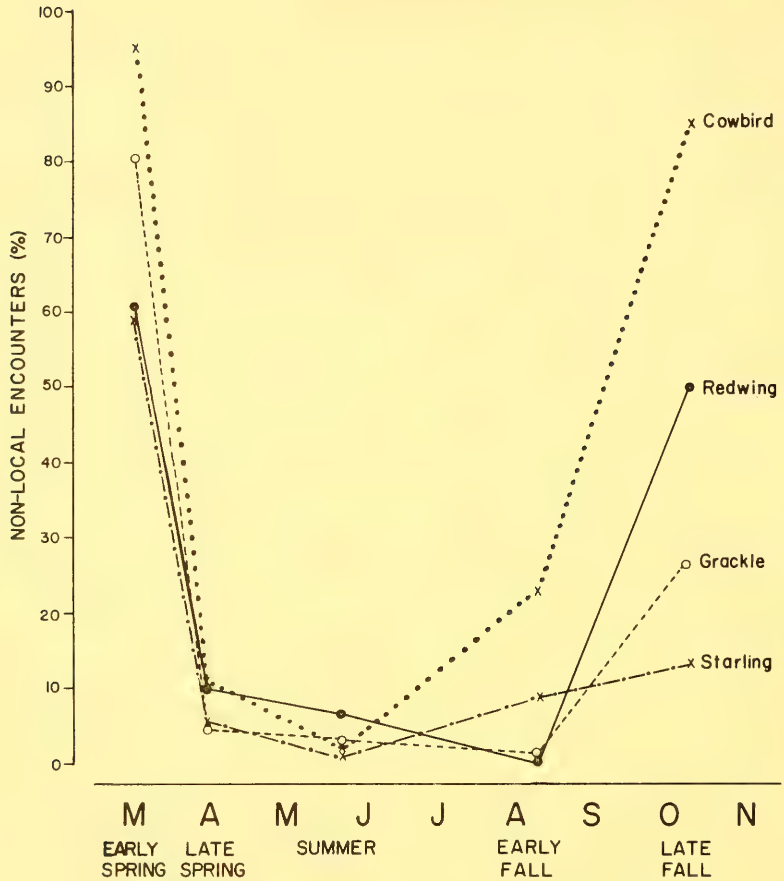

FIGURE 2. Percentage of total birds (from Table 1) encountered in the study region between 1 March and 15 November for which the other encounter was non-local, grouped by season and species.

Control efforts would probably occur during either the spring or fall roosting periods. During early spring, the majority of birds affected, for all four species, would probably not be those that breed locally nor those responsible for fall damage, although for Red-winged Blackbirds this pattern is based on very few returns. A control effect in late spring would affect predominantly local breeding birds, which are also present in the early fall, and (for Common Grackles and Starlings) late fall roosts.

A control effort in the early fall would be most effective against the Red-winged Blackbirds responsible for the damage. It would also affect the local late spring and breeding populations of all four species, and local late fall Common Grackle and Starling populations. The only populations present in the study region during other time periods that would be affected by a late fall control effort would be Starlings and Common Grackles.

In summary, the data suggest that, other than early fall, the only time that control efforts against Red-winged Blackbirds would be feasible, in affecting those birds responsible for local agricultural damage, would be late spring. Late spring and early fall control would affect local breeding populations of all four species and late fall populations of Common Grackles and Starlings. Although not as complete as one would prefer, the banding return data appear useful in answering some basic questions concerning the management of Red-winged Blackbirds. For an area such as the St. Lawrence Valley, however, more banding effort in the less populated areas to the north, or alternate research to determine the importance of birds from further north in fall crop damage, is required. The scarcity of agricultural land north of the St. Lawrence Valley will result in much less dense breeding populations since hay and pasture are the habitats contributing most to Red-winged Blackbird

TABLE 2 — Non-local encounter locations and numbers for blackbirds and Starlings encountered once within and once outside southwestern Quebec–eastern Ontario and banded and recovered between 1 March and 15 November

Period	Red-winged Blackbird		Starling		Common Grackle		Brown-headed Cowbird	
Early spring	New York	(1)	New York	(11)	New York	(7)	New York	(4)
	New Jersey	(1)	Pennsylvania	(7)	New Jersey	(23)	Massachusetts	(1)
			Ohio	(34)	Maryland	(2)	Rhode Island	(2)
			New Jersey	(4)	N. Carolina	(3)	New Jersey	(8)
			Maryland	(1)	S. Carolina	(1)	Pennsylvania	(5)
			Kentucky	(1)	Georgia	(1)	Virginia	(2)
			Tennessee	(5)			Georgia	(1)
			N. Carolina	(1)				
Late spring	New Jersey	(1)	New York	(1)	N. Quebec	(1)	Maine	(1)
	Georgia	(1)	Pennsylvania	(2)	Maine	(2)	Massachusetts	(1)
			N. Carolina	(1)	New York	(4)	Ohio	(2)
					N. Carolina	(1)	New Jersey	(1)
					Maryland	(1)		
Summer	N. Quebec	(1)	N.E. Quebec	(1)	N. Quebec	(4)	N. Quebec	(1)
	S. Ontario	(1)	New York	(1)	New York	(4)	Maine	(1)
	Pennsylvania	(1)	Pennsylvania	(1)				
			New Jersey	(1)				
Early fall			New York	(1)	Manitoba	(1)	New Jersey	(1)
			N. Carolina	(1)			Maryland	(1)
							Arkansas	(1)
Late fall	New Jersey	(2)	Ohio	(2)	New York	(1)	Maine	(2)
	Virginia	(1)	Tennessee	(2)	Ohio	(1)	Ohio	(2)
					New Jersey	(1)	New Jersey	(11)
					Maryland	(1)	Georgia	(1)
					Kentucky	(1)	Florida	(1)
					N. Carolina	(1)		

productivity (Dyer 1970; P. Weatherhead, unpublished data). The land area between the St. Lawrence Valley and the northern breeding limit for Red-winged Blackbirds (Godfrey 1966) is sufficient, however, to allow the possibility that these birds, if concentrated in the St. Lawrence Valley in early fall, could be having a significant impact on agriculture.

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Notes

Summer Ranges, Cover-type Use, and Denning of Black Bears near Fort McMurray, Alberta

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Fuller, Todd K. and Lloyd B. Keith. 1980. Summer ranges, cover-type use, and denning of Black Bears near Fort McMurray, Alberta. Canadian Field-Naturalist 94(1): 80–83.

Radiocollared Black Bears (*Ursus americanus*) were studied near Fort McMurray, Alberta, during June–October 1976. Four females without cubs occupied areas averaging 7.5 km^2. During summer and fall, stands of spruce (*Picea* spp.) and open muskegs were used less often than predicted from random sampling, whereas mixed aspen (*Populus tremuloides*) and Jack Pine (*Pinus banksiana*) were used more often. Six radiocollared bears denned between 19 September and 29 October. Five dens were excavated on level ground; four were in stands (< 15 cm DBH) of mixed aspen and birch (*Betula papyrifera*) and had likely been dug in previous years.

Key Words: Black Bear, *Ursus americanus*, home range, cover-type use, denning, Alberta.

Ongoing development of the Athabasca Oil Sands in northeastern Alberta is subjecting Black Bear (*Ursus americanus*) and other big-game populations to increased human disturbance. Little has been published, however, on Black Bear ecology in the boreal forest of Canada. During June–September 1976, while live-trapping wolves (*Canis lupus*) for the Alberta Oil Sands Environmental Research Program (AOSERP) near Fort McMurray, we captured and radiocollared six Black Bears. This paper describes the size of the areas over which the bears ranged during June–October, their use of different vegetation types, and their denning.

Study Area

Our bears were radiocollared near the abandoned oil plant and townsite of Bitumount, 75 km N of Fort McMurray. The study area was bordered by the Athabasca River on the west and included the Fort Hills on the east (Figure 1). Other than in the Fort Hills, which rise about 100 m above the surrounding landscape, topography is relatively flat. Dominant vegetation includes pure and mixed stands of Jack Pine (*Pinus banksiana*), Trembling Aspen (*Populus tremuloides*), and White Spruce (*Picea glauca*) on upland sites; Black Spruce (*Picea mariana*), willows (*Salix* spp.), and open muskeg occur in the lowlands. The Fort Hills are covered predominantly by aspen. Willows and Balsam Poplar (*Populus balsamifera*) are common on islands and banks of the Athabasca River.

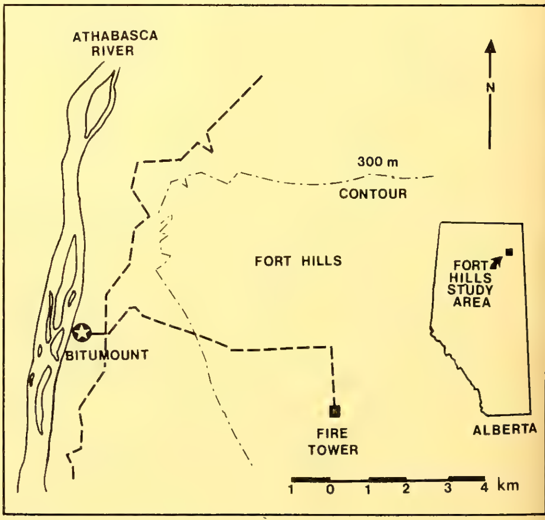

FIGURE 1. Map of Fort Hills study area in Alberta. Dashed lines indicate driveable trails.

Methods

Four of the six bears were captured in steel traps between 29 June and 4 July; the two others were caught in Aldrich foot snares (Troyer et al. 1961) on 24 and 28 September. All were immobilized with phencyclidine hydrochloride and promazine hydrochloride (Seal et al. 1970), weighed and measured, and had a tooth (P1) pulled for age determination (Stoneberg and Jonkel 1966). The six bears were individually marked with metal and colored-plastic ear tags, and fitted with a radiocollar (151 mHz).

Radiolocations were made from fixed-wing aircraft (Mech 1974) or obtained from triangulations on the ground. These were plotted on aerial photographs or

TABLE 1—Summary of capture, area occupied, and denning information for six radiocollared Black Bears on the Fort Hills study area during 29 June – 30 October 1976

Bear number	Date captured	Sex	Age (yr)[a]	Weight (kg)	Total number of relocations	Size of area occupied (km)[b]	Last relocation away from den site	First relocation at den site	Estimated denning
6082	29 Jun.	F	1.5	22	21	7.4	12 Oct.	20 Oct.	16 Oct.
6084	30 Jun.	F	3.5	41	18	7.0	19 Sep.	2 Oct.	26 Sep.
6021	4 Jul.	F	3.5	55	25	9.3	12 Oct.	20 Oct.	16 Oct.
6023	4 Jul.	F	7.5	83	20	6.2	12 Oct.	20 Oct.	16 Oct.
6015	28 Sep.	M	3.5	69	11	×[c]	20 Oct.	29 Oct.	24 Oct.
6017	24 Sep.	M	5.5	80	7	×[c]	5 Oct.	20 Oct.	12 Oct.

[a]From tooth-cementum annuli (Stoneberg and Jonkel 1966).
[b]Estimated by minimum-perimeter polygon method (Mohr 1947).
[c]Not estimated owing to short radiotracking period.

forest-cover maps (1:63 360) and transformed to metric-grid coordinates. Radiolocations averaged 5.5 d (± 3.3 SD) apart; 76% of the 96 relocations were made from the air. Bears were sighted on only 14% of aerial relocations owing to dense foliage. The size of the area occupied by each animal was estimated by the minimum-perimeter polygon method (Mohr 1947).

Cover-type distribution was determined from Alberta Forest Cover Maps, aerial photographs, and aerial reconnaissance flights; cover-type availability within each individual's range was calculated using dot-grid overlays.

Den sites were located and examined after the bears had first entered hibernation; none were removed and thus den chambers were not examined.

Results

The six bears (four females, two males) taken by us varied in age from 1.5 to 7.5 yr (Table 1). The 7-yr-old female was without cubs, as were the two 3-yr-olds; this would be expected with the latter (Erickson et al. 1964; Rogers 1976). Of these, only the older female was in estrus when caught, though all three were taken within 4 d (30 June – 4 July).

The size of areas within which the four radiocollared females ranged during July to October was similar (Table 1), averaging 7.5 km^2 (6.2–9.3 km^2). The largest area encompassed a fire tower where at least four people and four dogs were present throughout the summer.

Although we likely did not capture all female bears in the vicinity, the occupied ranges of three with radiocollars were adjacent and largely exclusive of one another (12% mean overlap). The periphery of the fourth female's range was 1.1 km from that of the nearest other radiocollared female. Both of the radiocollared males were taken at the same site within the range of a marked female.

In general, use of various cover types by radiocollared females reflected availability (Table 2); however, aspen-conifer mixes (especially Trembling Aspen-Jack Pine) appeared to be utilized more often, and stands of White and Black Spruce less often, than expected from relative availability.

TABLE 2—Cover-type use and availability within areas occupied by four radiocollared female Black Bears during June–October 1976. Number of radiolocations for which cover-type use was determined is shown in parentheses

Bear number	Ratio of percent locations within cover type to percent availability of cover type: Aspen	Aspen-Jack Pine	Jack Pine	White Spruce	Aspen-White Spruce	Black Spruce-muskeg
6082 (18)	67/53	11/8	0/7	0/5	11/3	11/23
6084 (15)[a]	60/66	33/10	0/1	0/5	7/3	0/15
6021 (20)[a]	30/43	35/2	0/14	0/15	25/8	10/18
6023 (18)	17/13	22/20	61/52	0/1	0/1	0/13
Total (71)[a]	42/44	25/10	15/19	0/7	11/4	6/17

[a]Percent of locations within cover types significantly different from cover-type availability (chi-square test; $P < 0.05$).

Our best estimates of denning by radiocollared bears varied from 26 September to 24 October (Table 1). One male (No. 6015) abandoned his den when we approached it on 30 October.

All four females denned on or near the periphery of the ranges they occupied during July-August; Tietje and Ruff (1980) reported this same tendency.

At least five of six den sites had been excavated. Four were on level ground in young stands (mean, 12 cm DBH) of mixed aspen and birch (*Betula papyrifera*). Three of the dens had horizontal entrances averaging 20 cm in diameter; the fourth entrance was slightly angled and adjacent to a decayed falled log. Leaves had been scraped into all four dens from up to 5 m away, and partly plugged the entrances. Low and well-eroded piles of sandy soil lay nearby, suggesting that these dens had been dug in previous years.

Adult female 6023 excavated a cavity under the roots of a standing Jack Pine (25 cm DBH). Two large entrances (30 and 40 cm diameter) on either side of a root led into a single chamber extending at least 1.5 m below ground. Large piles of fresh sandy soil, 3–4 m from the entrance, indicated that the den was newly excavated. Unlike the other four dens, there was little debris at or near the entrance.

The den of the sixth bear, an adult male, was not examined. It was apparently situated on an island in the Athabasca River where large Balsam Poplar logs had washed onto willow flats.

Discussion

Home range sizes of adult and yearling female Black Bears studied elsewhere by radiotelemetry have varied greatly: 2.3 km^2 (Lindzey and Meslow 1977) and 5.1 km^2 (Poelker and Hartwell 1973) in Washington; 9.6 km^2 (Rogers 1977) in Minnesota; 19.6 km^2 (Young 1976) at Cold Lake, Alberta; and 48.9 km^2 (Amstrup and Beecham 1976) in Idaho. Differences in range sizes of bears, both within and between regions, are likely due to differences in resource availability (Lindzey and Meslow 1977). Although females on the Fort Hills study area were not tracked in May and June, their estimated mean home range of 7.5 km^2 can likely be compared to annual home-range estimates of other researchers. Lindzey and Meslow (1977), for example, reported that adult female bears without cubs tended to use their entire home range year round, and six bears tracked by Young (1976) during the summer and fall only, had ranges averaging 20.5 km^2 vs. an overall spring–fall mean of 19.6 km^2.

At Cold Lake, 300 km to the south, Young (1976) reported that during May–October adult male Black Bears avoided muskegs, were attracted to dump sites, and used upland habitats relative to their availability. Higher-than-expected use of aspen, aspen-Jack Pine, or aspen-conifer mix in both the Fort Hills and at Cold Lake likely reflected the abundance of berries (*Vaccinium* spp.), a major food source within such cover types (Rogers 1976; Young 1976).

Den entry dates of Black Bears studied outside of Alberta have ranged from early October through November (Amstrup and Beecham 1976; Lindzey and Meslow 1976; Erickson 1965; Erickson et al. 1964; Jonkel and Cowan 1971; Rogers 1970). Dates appear to be most determined by weather and/or food availability (Jonkel and Cowan 1971; Tietje and Ruff 1980). At Cold Lake, Tietje and Ruff (1980) reported that bears denned from early to mid-October in 1976, as in the Fort Hills.

After an extensive review of the literature, Tietje and Ruff (1980) concluded that the proportion of bears excavating dens is correlated with decreasing winter temperatures and thus the need for increased insulation. At Cold Lake, where the mean daily minimum temperature in January is -20° C, 35 of 37 dens were excavated (Tietje and Ruff 1980). Winter temperatures are equally low in the Fort Hills and all five dens examined were excavated.

Acknowledgments

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Records of Hibernating Big Brown Bats (*Eptesicus fuscus*) and Little Brown Bats (*Myotis lucifugus*) in Northwestern Ontario

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Nagorsen, D.W. 1980. Records of hibernating Big Brown Bats (*Eptesicus fuscus*) and Little Brown Bats (*Myotis lucifugus*) in northwestern Ontario. Canadian Field-Naturalist 94(1): 83–85.

Torpid Big Brown Bats (*Eptesicus fuscus*) occurred in three hibernacula in northwestern Ontario. This is the first evidence that sizeable populations of this species overwinter in northern Ontario. The hibernacula are described; two contained torpid Little Brown Bats (*Myotis lucifugus*).

Key Words: Big Brown Bat, *Eptesicus fuscus*, Little Brown Bat, *Myotis lucifugus*, bat hibernacula, temperature, northern Ontario.

The distribution of caves and mines used as bat hibernacula in northern Ontario was reviewed by Fenton (1970, 1972). Although several are situated near the north shore of Lake Superior (Figure 1), hibernacula have not been reported in Ontario west of Lake Superior. In March 1979 I found torpid Big Brown Bats (*Eptesicus fuscus*) and Little Brown Bats (*Myotis lucifugus*) at three hibernacula in northwestern Ontario (Figure 1).

Big Brown Bats were readily identified by size and pelage. Smaller bats that were found in two hibernacula were identified using the keys in Peterson (1966). Populations of Little Brown Bats reported here could have included individuals of Eastern Long-eared Bats (*Myotis septentrionalis*) as only 40–50 small bats were examined in hibernacula to minimize disturbance. Voucher specimens taken from hibernacula were deposited in the Department of Mammalogy, Royal Ontario Museum. Temperatures at roosting sites were measured with a Taylor pocket thermometer accurate to 1°C.

The three hibernacula studied were New Campbell Island Mine, Lime Bay Overpass Tunnel at Caland Mine, and Margaret Lake Diversion Tunnel. New Campbell Island Mine is a uranium mine, abandoned since the 1950s, situated in McNicol Township about 40 km E of Kenora (49°49′N, 93°53′W). The mine consists of a large adit 180 m long with three passages 10–70 m in length and a small adit about 70 m long. On 26 March I estimated that the mine contained 150 Big Brown Bats and 150 Little Brown Bats. In the large adit most Big Brown Bats were 120–150 m from the entrance where the temperature was 2°C. Little Brown Bats roosted near the end of the passages where temperatures were 3–4°C. The small adit contained mostly Big Brown Bats. Although 45 Big Brown Bats roosted singly, 18 clusters contained 2–24 individuals ($\bar{x}$ = 5.8). The 28 clusters of Little Brown Bats contained 2–16 bats ($\bar{x}$ = 5.3); only 6 Little Brown Bats roosted singly.

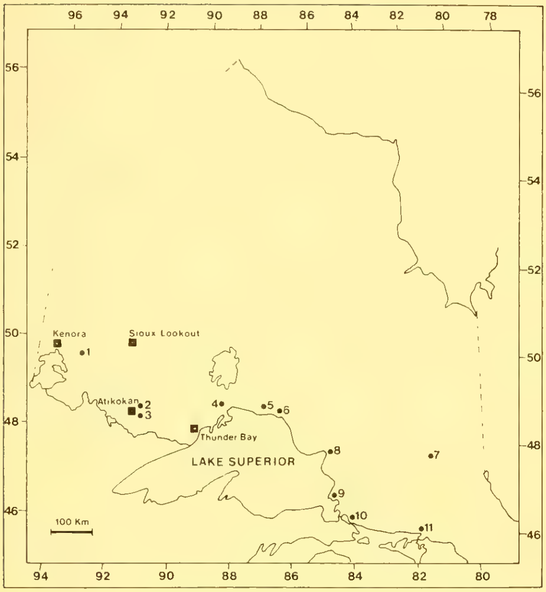

FIGURE 1. Locations of bat hibernacula in northern Ontario: 1, New Campbell Island Mine; 2, Lime Bay overpass tunnel at Caland Mine; 3, Margaret Lake diversion tunnel; 4, Cavern Lake Cave; 5, Schreiber Mine; 6, Empress Mine (Jackfish Mine); 7, Gowganda Mine; 8, Wawa Mine; 9, Alona Bay Mine; 10, Desbarets Cave; 11, Webbwood Mine. Hibernacula 4–11 are from Fenton (1970).

Lime Bay Overpass Tunnel is situated on the property of the Caland Mine in Schwenger Township, 7 km N of Atikokan (48°49′N, 91°36′W). Once used as a conveyer tunnel, it ceased operating in the early 1960s and was closed at one end. The tunnel, which is about 350 m long, is protected from draughts. On 28 March I found about 70 Big Brown Bats and 190 Little Brown Bats hibernating there. Big Brown Bats roosted at sites with temperatures of 2–3°C about 100–150 m from the entrance. Although 37 Big Brown Bats roosted singly, 12 clusters contained from two to eight bats ($\bar{x}$ = 2.8). Little Brown Bats roosted at the end of the tunnel where temperatures varied from 6 to 8°C. The number of bats in the 38 clusters counted varied from 2 to 12 individuals ($\bar{x}$ = 4.9). About 20 Little Brown Bats roosted singly. Most clusters of Little Brown Bats were located on the ceiling in areas where water seeped into the tunnel resulting in the fur of many bats being soaked by water.

Margaret Lake Diversion Tunnel is located 3 km NE of Atikokan in Schwenger Township (48°46′N, 91°33′W). This tunnel was apparently constructed in the early 1950s and is 250 m long, open at both ends and exposed to considerable air movement. Water was flowing through the tunnel when I examined it on 24 March. Four Big Brown Bats were roosting in drill holes in the ceiling where temperatures were 0–3°C. No other bats were found in the tunnel.

Discussion

These records demonstrate that populations of 70–150 Little Brown and Big Brown Bats overwinter at suitable hibernacula west of Lake Superior in Ontario. The New Campbell Island Mine is the northern- and western-most bat hibernaculum known in Ontario. Little Brown Bats, which have been found in all the northern Ontario hibernacula studied by Fenton (1970), were known previously to overwinter as far north as Cavern Lake Cave (48°50′N, 88°40′W) in Ontario (Allin 1942).

Although Big Brown Bats have been collected as far north as Sioux Lookout in summer (Peterson 1966), this species has been found only sporadically in midwinter at hibernacula in northern Ontario. In a 7-yr study (1965–1971) Fenton (1972) did not observe Big Brown Bats at northern Ontario hibernacula and suggested that this species might migrate south to overwinter. Published records of Big Brown Bats hibernating in northern Ontario are based on a few individuals found in hibernacula near the north shore of Lake Superior. In November 1941 two Big Brown Bats were hibernating at Cavern Lake Cave (Allin 1942). From 1967 to 1971 a census of hibernating bats revealed that one to nine Big Brown Bats overwintered in this cave (D. Woodside and R. Buchanan, 1975. Cavern Lake bat cave. A study and recommendations for management. Environment Planning Series VI, 1 (Miscellaneous unpublished report), Ontario Ministry of Natural Resources. 54 pp.). Fenton (1972) reported a torpid Big Brown Bat in the Schreiber Mine in the same general area in February.

The apparent absence of Big Brown Bats from most northern Ontario hibernacula studied by Fenton (1970, 1972) is puzzling. As these roosts contain populations of hibernating Little Brown Bats, it is unlikely that low temperatures prohibit Big Brown Bats from overwintering at these sites. In this study and elsewhere (Hitchock 1949; Fenton 1972), Big Brown Bats hibernated in cooler and more exposed roosting sites than Little Brown Bats. These northern Ontario hibernacula may be unsuitable for Big Brown Bats because of high humidity. Fenton (1970) reported more moisture in northern Ontario hibernacula than in hibernation sites from southern Ontario and he observed that bats covered with droplets of water were more common in northern hibernacula. Several studies (see Rysgaard 1942; Hitchcock 1949) have shown that Big Brown Bats select drier hibernation sites than do Little Brown Bats. It is interesting to note that in

the Caland Mine tunnel near Atikokan no Big Brown Bats roosted in wet areas of the tunnel where Little Brown Bats hibernated. Fenton (Carleton University, personal communication) suggested that roosting sites in these northern Ontario hibernacula lack the appropriate combination of temperature and humidity necessary for hibernating Big Brown Bats. Little Brown Bat hibernation sites, which are usually in dead-end tunnels, may be too warm and moist for Big Brown Bats; more exposed areas near entrances may be too cool. More research on the microclimate in these northern Ontario hibernacula is required.

According to Fenton (1970, 1972), three species of bats, the Big Brown Bat, Little Brown Bat, and Eastern Long-eared Bat overwinter in northern Ontario. Little is known about the climatic factors that may determine the northern limits of hibernating populations of these species. Mean minimum January isotherms (as drawn by Chapman and Thomas 1968) show that areas bordering Lake Superior are 2–6°C warmer than areas at comparable latitudes situated away from the influence of the lake. Fenton (1972) speculated that the presence of Big Brown Bats in several hibernacula near Lake Superior could be a result of this moderating effect on winter temperatures. But the records reported here of Little Brown Bats and Big Brown Bats hibernating near Kenora and Atikokan and specimen records (Royal Ontario Museum) of Little Brown Bats and Eastern Long-eared Bats hibernating in the Gowganda Mine, Kirkland Lake District (Figure 1) demonstrate that these species hibernate in northern Ontario at considerable distances from the Great Lakes.

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I am grateful to W. MacRae, Geologist with the Ontario Ministry of Natural Resources (OMNR) for providing information and maps of potential hibernacula in Atikokan District. R. Beard, Regional Geologist at Kenora (OMNR) gave useful information on the New Campbell Island Mine. Eldon Cornell, surveyor with Caland Mine, kindly showed me the overpass tunnel on the Caland property. I thank J. R. Tamsitt, R. L. Peterson, and M. B. Fenton for critically reviewing the manuscript and J. Nelson for assisting with field work. This research was supported by the Royal Ontario Museum.

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Dutchman's Breeches, *Dicentra cucullaria,* New to Manitoba

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Pavlick, Leon E. 1980. Dutchman's Breeches, *Dicentra cucullaria,* new to Manitoba. Canadian Field-Naturalist 94(1): 85–86.

Key Words: *Dicentra cucullaria,* Dutchman's Breeches, range extension, Manitoba flora.

The known range of *Dicentra cucullaria* in Canada has been reported by Scoggan (1978–1979) as extending from Ontario to New Brunswick and Nova Scotia. This, the eastern variety, *D. cucullaria* var. *cucullaria,* ranges in the United States from eastern North Dakota, south to Kansas and Nebraska, and east to the Atlantic coast from Quebec to Georgia (Hitchcock et al. 1964). The western variety, *D. cucullaria* var. *occidentalis* occurs in the Columbia River system of Washington, Oregon, and Idaho, and is disjunct from

the eastern variety (Hitchcock et al. 1964).

Monserud and Ownbey (1971) indicated that *D. cucullaria* occurs throughout Minnesota except in the northwestern and Canadian border areas. Morley (1966) states that it occurs north to Beltrami County, Minnesota, which is within 175 km south of Manitoba. Lakela (1965) records it in the southern half of St. Louis County, Minnesota, about 250 km SE of the southeastern corner of Manitoba. Scoggan (1957) does not list the species for Manitoba in his *Flora of Manitoba.* There are no specimens of it at any of the major herbaria in Manitoba nor any other records of it being collected in Manitoba (K. L. Johnson, Curator of Botany, Manitoba Museum of Man and Nature, personal communication).

On 24 May 1974, I collected *Dicentra cucullaria* near Whitemouth Lake in southeastern Manitoba (approximately 49°15′30″N, 95°43′30″W). Several plants were observed at that time, occurring in a rich wood of *Ulmus americana* (American Elm) and *Fraxinus* sp. (Ash). Associated herbs included *Caulophyllum thalictroides* (Blue Cohosh), *Sanicula marilandica* (Black Snakeroot), and *Osmorhiza longistylis* (Aniseroot).

The specimen (L. E. Pavlick 74-1) has been deposited in the herbarium of the Manitoba Museum of Man and Nature, Winnipeg, Manitoba.

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Additions to Manitoba's Aquatic Macrophyte Flora

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Pip, Eva. 1980. Additions to Manitoba's aquatic macrophyte flora. Canadian Field-Naturalist 94(1): 000–000.

A survey of submerged macrophytes in southern Manitoba revealed new records for *Potamogeton obtusifolius, P. spirillus, Myriophyllum farwellii,* and *Eriocaulon septangulare* from the southeastern portion of the province, which represented northwestward range extensions of up to 300 km. Additional records were confirmed for *Zosterella dubia, Potamogeton amplifolius,* and *Brasenia schreberi.*

Key Words: Manitoba flora, macrophytes, new records, aquatic plants.

Of the 315 stations in southern Manitoba surveyed during 1974–1978 for submerged macrophytes, 13 stations in the eastern part of the province yielded new floristic records. In addition, several records previously regarded as doubtful were confirmed. Voucher specimens have been deposited in the University of Manitoba Herbarium (UMH).

New Records

Potamogetonaceae

Potamogeton obtusifolius

Gleason (1952) placed the range of this species in eastern Canada and the northeastern United States, west to Minnesota and western Ontario. In Manitoba, this species was collected at the following localities: small, slow creeks draining into Brereton Lake (49°48′N, 95°25′W); Rennie River, a slow stream (49°55′N, 95°24′W); south shore, Eleanor Lake (50°09′N, 95°37′W); lake (51°00′N, 95°15′W); drainage ditch (50°53′N, 95°14′W); small creek draining into Lyons Lake (49°34′N, 95°09′W); Beaver Creek, a slow stream (51°37′N, 96°46′W) (UMH Nos. 30123–26, 34185–87). The first three of these stations were located in Whiteshell Provincial Park, while the last, on the west shore of Lake Winnipeg, represented a northwestward range extension of 300 km. Surface

water at the sites where this species was present ranged in pH from 6.4 to 8.0, total filtrable residue 38–179 mg/L, total alkalinity 14–76 mg/L $CaCO_3$, molybdenum blue phosphorus 0.44–1.21 mg/L, combined nitrite and nitrate from below measurable levels to 1.19 mg/L, and chloride from below measurable levels to 26 mg/L. Sulphate was below measurable levels at all sites. Water chemistry was determined using methods recommended by the American Public Health Association (1971). This species was found on substrates which ranged from granitic bedrock to sand and gravel, but all were covered to some extent by organic matter. Its apparent tendency to occur in slow-moving waters supports the observations of Hotchkiss (1967) for this plant in other parts of its range.

Potamogeton spirillus

The range of this species was given by Gleason (1952) as extending from eastern Canada to Minnesota and South Dakota. In Manitoba this plant was found at the following localities: Jessica Lake (50°00′N, 95°15′W); small creek (49°40′N, 95°09′W); Lyons Lake (49°33′N, 95°09′W) (UMH Nos. 30149–51). The first two of these sites were located in Whiteshell Provincial Park and constituted a northward range extension of approximately 200 km at the western end of the range for this species. The surface water chemistry at these three sites showed the following values: pH 7.0–8.2, total filtrable residue 67–109 mg/L, total alkalinity 16–58 mg/L $CaCO_3$, chloride from below measurable levels to 6 mg/L, sulphate from below measurable levels to 4 mg/L, molybdenum blue phosphorus 0.33–1.50 mg/L, combined nitrate and nitrite 0.60–0.70 mg/L. Although these ranges appeared to be quite narrow because of the small number of sites under consideration, this species was found in a wider range for these variables in areas southeast of Manitoba where it was more common (Pip 1979). At the sites in Manitoba the substrate consisted of granitic bedrock, gravel and sand covered with organic matter, and was similar to that of more southerly habitats for this species reported by Pip (1979).

Haloragaceae

Myriophyllum farwellii

Gleason (1952) stated that this species ranges from Quebec and Connecticut west to Minnesota. In Manitoba it was found at Hanson Creek (49°43′N, 95°11′W) in Whiteshell Provincial Park, and in the river connecting Davidson and Star Lakes (50°22′N, 95°10′W) in Nopiming Provincial Park (UMH Nos. 34179–80). The latter record constituted a northward range extension of approximately 300 km at the western end of the range for this species. The surface water chemistry at these two sites gave the following respective values: pH 5.5, 6.6; total filtrable residue 62, 15 mg/L; molybdenum blue phosphorus 0.23, 0.48 mg/L; combined nitrate and nitrite below measurable levels and 0.22 mg/L. Both sites had a total alkalinity of only 4 mg/L $CaCO_3$, while chloride and sulphate concentrations were below measurable levels. Both sites were streams with a moderate current and with a bottom of granitic bedrock covered by organic matter. Little is known concerning the ecology of this plant in other parts of its range.

Eriocaulaceae

Eriocaulon septangulare

Gleason (1952) gave the range of this species as extending from eastern Canada and the northeastern United States, west to Minnesota. In Manitoba it was found at Green Lake (57°07′N, 95°19′W) in Whiteshell Provincial Park (UMH Nos. 30056, 34200). This record constituted a northwestward range extension of approximately 300 km. The surface water at this site showed the following values: pH 8.6, total filtrable residue 41 mg/L, total alkalinity 16 mg/L $CaCO_3$, molybdenum blue phosphorus 0.09 mg/L, combined nitrate and nitrite 0.92 mg/L. Chloride and sulphate concentrations were below measurable levels. The plants were found growing partially emergent from the water in a crevice filled with organic matter, in the granitic bedrock bottom. This habitat type differed from that cited for this genus by Prescott (1969), who reported that in the United States these plants generally occur in sandy, acid conditions. The presence of an organic substrate agrees with the observations of Haslam et al. (1975) for this species in Britain.

Confirmed Records

Zosterella (= *Heteranthera*) *dubia* (Pontederiaceae), first reported from Manitoba by Pip and Paulishyn (1971), was recorded during the present study at eight stations in southeastern Manitoba and on the west shore of Lake Winnipeg. This species appeared to be particularly sensitive to high total alkalinity values, the highest recorded value being 112 mg/L $CaCO_3$. *Potamogeton amplifolius* (Potamogetonaceae) was cited from Manitoba by several workers (e.g., Ogden 1943; Lowe 1943 *in* Scoggan 1957), as was *Brasenia schreberi* (Nymphaeaceae) (e.g., Rydberg 1932 *in* Scoggan 1957), but Scoggan (1957) tentatively excluded these species from the flora of the province because of the lack of verifiable specimens. During the present study, *P. amplifolius* was recorded at 13 stations, where the water showed low values for total filtrable residue (18–170 mg/L) and total alkalinity (10–119 mg/L $CaCO_3$). *Brasenia schreberi* was found at two stations in Whiteshell Provincial Park, where the respective water chemistry values were pH 6.4, 8.6; total filtrable residue 41, 45 mg/L; total alkalinity 4,

16 mg/L $CaCO_3$; molybdenum blue phosphorus 0.09, 0.16 mg/L; combined nitrate and nitrite below measurable levels and 0.92 mg/L. Both sites had chloride and sulphate concentrations below measurable levels.

All of the above records relate to waters of the Precambrian Shield and to sites with similar low dissolved solids on the west shore of Lake Winnipeg. The most important factor which appears to influence the distributions of these predominantly eastern species with respect to water quality is total alkalinity (Pip 1979). It is probable that the more alkaline waters of the western portions of the province present a barrier to any further westward expansion of the ranges of these species.

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Polar Bear Predation on Ringed Seals in Ice-free Water

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Donald J. Furnell, and David Oolooyuk. 1980. Polar Bear predation on Ringed Seals in ice-free water. Canadian Field-Naturalist 94(1): 88–89.

An adult Polar Bear (*Ursus maritimus*) was observed catching a free-swimming Ringed Seal (*Phoca hispida*). Additional evidence of successful predation on seals was found on beaches.

Key Words: Polar Bear (*Ursus maritimus*), Ringed Seal (*Phoca hispida*), predatory behavior, feeding behavior.

Seals constitute the major prey of Polar Bears (*Ursus maritimus*) throughout their circumpolar range. In the Canadian Arctic, bears feed primarily on Ringed Seals (*Phoca hispida*) with Bearded Seals (*Erignathus barbatus*) and Harp Seals (*Phoca groenlandica*) taken to a lesser extent (Stirling and McEwan 1975). Most published information on hunting by Polar Bears has dealt with predatory behavior on sea ice, specifically the capture of seals at winter breathing holes; in subnivean birthing lairs; and on spring ice when seals haul out for the annual molt (Stirling and Archibald 1977; Stirling and Latour 1978).

Seals are most vulnerable to Polar Bear predation in spring when giving birth or as pups and when molting. With this abundant food supply, bears develop reserves of fat before summer. These fat reserves are believed to carry Polar Bears through summer (Knudsen 1973), although supplementary feeding on carrion, tundra berries and grasses, ground-nesting birds and their young, microtine rodents, swimming birds, marine algae and invertebrates, and cubs of their own species has been reported (Russell 1975). Polar Bears are powerful swimmers and can submerge for over 2 min, but they cannot match the

speed and agility of seals in water. Therefore Polar Bears were believed incapable of catching seals in open water during the summer months (Russell 1975; Stirling and McEwan 1975). Although Polar Bear behavior at summer retreats is generally lethargic (Knudsen 1973) and thought correlated with limited access to prey, some evidence exists that Polar Bears may catch seals with little or no ice present (Albert Hochbaum, personal communication; Inuit anecdotes). Our observations confirm Polar Bears' ability to prey on free-swimming seals.

Observations and Discussion

The observations were made incidental to a study examining techniques for live-capturing bears at Wager Bay, Northwest Territories (65°26'N, 88°40'W). The single direct observation of successful hunting, made 29 August 1978, involved an adult male bear weighing approximately 350 kg. We initially sighted the bear swimming in shallow water near shore while its prey, a medium-sized Ringed Seal, was 50–70 m farther offshore. The Polar Bear swam rapidly toward its prey when the seal's head was above the surface. When the seal submerged, the bear stopped its pursuit and floated motionless. This pattern was repeated five times in our presence, although activity before our arrival was unknown. With each subsequent resurfacing and pursuit sequence, the gap between predator and prey decreased. The stalk ended when the seal surfaced less than 0.5 m from the bear's side. With a sudden lunge, the bear bit into the seal's back, killing it instantly. On 2 September 1978, a large lone bear, swimming 0.5 km offshore, was observed carrying a dead seal in its mouth. We speculated that a floating, motionless Polar Bear could be mistaken for an ice floe, inducing a seal to surface nearby.

Polar Bears of all age-sex classes were frequently seen swimming in the vicinity of camp, but we could not determine whether they were hunting. On warm clear days at the study site, Polar Bears restricted their activities to crepuscular and nocturnal patterns and relatively little evidence of predation was observed. During the frequent periods of combined rain, fog, wind, and poor visibility, Polar Bears were active throughout the day and we found seal carcasses along the shoreline. On a single morning, after 2 d of foul weather, four fresh kills were located along a 50-km stretch of coast. Much of the coast had vertical cliffs rising directly from the water, thus providing only limited areas for Polar Bears to bring seals ashore and feed. Each fresh carcass was stripped of the hide and blubber, a typical feeding pattern of Polar Bears (Stirling and McEwan 1975). Abandoned carcasses remained on beaches for only a few days before being consumed by Arctic Foxes (*Alopex lagopus*), Common Ravens (*Corvus corax*), gulls (*Laridae*), and other bears.

This hunting behavior may not be common to Polar Bears throughout their range and it is possible some of the seals we observed as carcasses were taken while they were basking on shore; however, we saw only one seal out of water and that sunning on a small intertidal rock. The high density of Ringed Seals in the area, once recorded at a concentration of 70 individuals in approximately 0.06 km^2, may have contributed to the hunting success of Polar Bears in Wager Bay. Although Bearded Seals represented roughly 5% of the area's pinniped community, we did not find evidence of Polar Bears killing them. It was not possible to determine whether all age-classes and both sexes of Polar Bears could catch free-swimming seals, although the abandoned remains of kills would benefit all members of the resident population. Our observations establish that some Polar Bears are capable of capturing free-swimming seals and do not rely entirely on scavenging and browsing for their summer diets.

Acknowledgments

We express sincere gratitude to Luke Siksik for his invaluable assistance and knowledge of the land. Norman Barichello and Ken Davidge provided much moral and physical support for the project's successful completion.

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Fisher Arboreal Activity

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Powell, Roger A. 1980. Fisher arboreal activity. Canadian Field-Naturalist 94(1): 90–91.

The movement of a Fisher (*Martes pennanti*) through the tops of trees in a hardwood forest is documented. Fisher arboreal activity as reported in the literature is discussed and it is concluded that the Fisher's arboreal abilities have been exaggerated.

Key Words: activity patterns, Fisher, *Martes pennanti*, literature reviews.

This note reports the first documented account of a Fisher (*Martes pennanti*) traveling through the tops of trees in a hardwood forest.

On 11 January 1979, R. B. Brander, B. J. Gillingham, and I were conducting a Porcupine (*Erethizon dorsatum*) census in the Ottawa National Forest of Upper Peninsula Michigan at approximately 46°12′ N, 88°52′ W. Snow depth was about 45 cm and the most recent snowfall had been less than 1 cm on 9 January 1979. Fisher tracks were found that had been made prior to that snowfall and apparently following any previous heavy snowfall. The tracks showed an extraordinary amount of arboreal activity. The Fisher climbed up a 15-cm-dbh Sugar Maple (*Acer saccharum*) and then jumped, landing approximately 3 cm from the tree. The track then led to a 25-cm-dbh Eastern Hemlock (*Tsuga canadensis*) from which the Fisher again jumped some 3 m. The impact of the Fisher landing had produced a trench of packed snow approximately 15 cm deep. The Fisher then ran approximately 10 m to a small (8-cm-dbh) Ironwood or Hop Hornbeam (*Carpinus caroliniana*), climbed that tree, and came down another small Ironwood some 4 m away. Because no large branches of the two Ironwoods intermingled, it is likely that the Fisher jumped from one tree to the other. Later that day I found another Fisher track wherein the Fisher had climbed a Sugar Maple (about 25 cm dbh), then came down another some 5 m away. Fisher tracks approached at least five Porcupine dens in the vicinity of the areas with arboreal activity. All tracks could have been made by the same Fisher. Marten (*Martes americana*) are not found in the Ottawa National Forest.

Accounts in the popular literature claim that the Fisher is North America's fleetest and most agile arboreal mammal (e.g., Haley 1975; Morse 1961). The source of this view appears to be a statement of Bachman quoted by Seton (1929) that Bachman had obtained a Fisher from a hunter who had shot it chasing a Marten in a tree. Seton also quoted a trapper as having seen a Fisher jump between trees. Grinnell et al. (1937) quoted two second-hand accounts of Fishers traveling through treetops.

None of the recent Fisher studies utilizing snow-tracking or direct observation (Coulter 1966; de Vos 1952; Powell 1977) have found evidence that Fishers travel from tree to tree without returning to the ground. De Vos (1952), after finding little evidence of any arboreal activity, speculated that the Fisher's arboreal abilities had been over-rated. Coulter (1966) found no evidence of Fishers having traveled from tree to tree in his study, nor did I (Powell 1977) in following over 150 km of Fisher tracks. I did find evidence that large male Fishers may even be clumsy in trees (Powell 1977). It is therefore of interest that recent evidence has been found of a Fisher traveling from tree to tree in a hardwood forest without returning to the ground.

The accounts presented by Seton (1929) and Grinnell et al. (1937) of the Fisher's arboreal activity were of observations made in extensive conifer forests. The studies of de Vos (1952), Coulter (1966), and Powell (1977) occurred in mixed conifer-hardwood forests. Fishers may find it easier to travel arboreally through extensive conifer forests than through hardwood forests. It is also likely that the observations reported were of Fishers forced to travel through the treetops because they were pursued by hunters and dogs on the ground. Although Fishers have partially retractable claws (Powell 1977) and descend trees head first (Coulter 1966; Grinnell et al. 1937; Powell 1977) by rotating their hind feet, anatomical evidence suggests that the Fisher's arboreal abilities are mostly derived from a generalized (not highly adapted) skeleton (Leach 1977).

Most evidence indicates that de Vos (1952) was correct in suggesting that Fisher arboreal abilities have been exaggerated.

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Brown Bear Kills Gray Wolf

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Ballard, Warren B. 1980. Brown Bear kills Gray Wolf. Canadian Field-Naturalist 94(1): 91.

Ground examination indicated a Brown Bear (*Ursus arctos*) had killed a Gray Wolf (*Canis lupus*) at an adult Moose (*Alces alces gigas*) carcass in southcentral Alaska. The observation represents first published evidence of a Gray Wolf mortality inflicted by a Brown Bear.

Key Words: Gray Wolf, *Canis lupus*, Brown Bear, *Ursus arctos*, mortality, Moose kill, *Alces alces gigas*, interspecific relationships.

Several known and potential natural mortality factors have been described for Gray Wolves, *Canis lupus* (Mech 1970). This report describes a cause of mortality not previously documented.

On 25 September 1976 while conducting wolf ecology studies in the Nelchina Basin of southcentral Alaska, I aerially tracked a wolf pack (six gray and three black wolves) to an adult Moose (*Alces alces gigas*) kill. The Moose kill appeared to be less than 2 d old, on the basis of both color of exposed flesh and degree of consumption (50%).

The next day Alfred Lee, Lee's Air Taxi Service, found a dead Gray Wolf close to the kill and observed a Brown Bear (*Ursus arctos*) running from the site. The site was examined from the ground the following day. The dead adult male Gray Wolf was at the base of a White Spruce tree (*Picea glauca*) approximately 10 m from the Moose, and the Moose had been buried. Tracks, plus extensively disturbed vegetation and soil indicated a fight had occurred.

The wolf had numerous punctures on its throat and around its anus. At least three cervical vertebrae and the rear portion of the occipital condyle were crushed. The left rear femur was fractured.

Evidence indicated that the Brown Bear had killed the Gray Wolf. An alternate explanation is that other wolves had killed the animal. Because the victim had been a regular pack member, and the bone damage was not typical of other wolf-killed wolves examined, it seems unlikely that the wolf was killed by pack members.

Murie (1944) mentioned that it was not infrequent for bears to discover kills made by wolves and dispossess the wolf to assume ownership. This observation, however, is the first published evidence of Gray Wolf mortality inflicted by a Brown Bear. The importance of this type of mortality to Gray Wolf populations is unknown.

I am grateful to Thomas Balland for assisting with field observations.

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Letters

Feedback on the Rôles of *The Canadian Field-Naturalist*

My editorial "*The Canadian Field-Naturalist* — the *status quo* or a new direction?" (Canadian Field-Naturalist 93(1): 10–15, 1979) was written because of my sincere concern that The Ottawa Field-Naturalists' Club, as publisher, might change the future direction of the journal without the benefit of input from authors and readers. Although most members of the Council of the club don't realize how the journal operates and what varied functions it performs, nor indeed, the many problems the Editor has to face, the 1978 Council was reported to be uneasy about *The Canadian Field-Naturalist.* When individual Council members were asked to give their opinions of *The Canadian Field-Naturalist* (see minutes of 6 November Council meeting) these ran from one extreme (". . . feels that most of the membership have no use for it") to the other ("thinks it great that the club produces [= publishes] it").

The kind responses of thirteen people who took the time to write down their thoughts following publication of my editorial are indeed gratifying; other communications of appreciation and support have also been encouraging. The almost unanimously very positive statements for the maintenance of the *status quo* from those who expressed their views in writing should carry considerable weight with the special committee that will ultimately recommend to the Council what direction the journal should be taking. Moreover, the Council members surely are now more aware that some of the people "out there" really do care deeply about the future of the journal and that *The Canadian Field-Naturalist* has a continuing important rôle to play for the natural sciences.

LORRAINE C. SMITH, Editor.

The single letter expressing dissatisfaction with the present editorial policy is printed below.

For some years now the debate concerning the future and rôle of *The Canadian Field-Naturalist* has been skirting the fundamental issue by dealing with what must surely be universally accepted arguments for technical accuracy and credibility. The crux of the question, it seems to me, is how can *The Canadian Field-Naturalist* best support and encourage the development of first-rate field studies in Canada, while maintaining these standards of credibility and accuracy? I feel that this can best be achieved by (1) encouraging the amateur field-naturalist and (2) by maintaining the traditionally diverse nature of *The Canadian Field-Naturalist* through the accommodation of more observational and speculative study.

Over the last 10 years or so *The Canadian Field-Naturalist* has increasingly become 'The Canadian Field-Biologist.' Without reams of supporting data, a given argument or suggestion is quickly struck. This limits the scope of the examination of such findings and eliminates the possibility of such discussion indicating potential patterns and/or areas of further study and exploration. This approach hurts the amateur naturalist most as he is unlikely to have the resources to support the long-term, expensive studies that could generate such data.

An historical example of the value of informed speculation is the tremendous contribution to the scientific and economic development of western Canada made by John Macoun in the late 1800s. Let us not forget that this famous naturalist was, in a real sense, an amateur. A more contemporary example can be found in the works of Alexander Skutch, *the* authority on Central American birds. His training was in botany and yet this amateur ornithologist is making a tremendous contribution to our knowledge of birds and the ecology of tropical America. He has recently been quoted by Frank Graham (Alexander Skutch and the appreciative mind. Audubon 81(2): 83–117, 1979) as objecting to ". . . the chart and table-studded articles that are now in fashion. 'For myself, each year I incline more and more strongly to put confidence in those rare flashes of sympathetic understanding that seem to penetrate the outer husk of a bird and reveal the life within . . . .' "

This then is my plea for a fuller recognition of the value of those 'flashes of sympathetic understanding' which are the field-naturalist's stock-in-trade. Certainly a statistically significant data base supporting the thesis of a paper is the ideal, but should not be so all-prevading a preference as to eliminate the opportunity for sound and inspired speculation. The two styles are not incompatible. By suggesting (as some do) that the latter style of paper be published in regional journals only, we are saying that such papers are of no national significance. The contribution of the 'amateurs' Macoun and Skutch should be enough to demonstrate the fallacy of this concept.

I fear that the unique balance that has set *The Canadian Field-Naturalist* apart from the other environmental studies journals is endangered by this changing publication policy. The journal seems increasingly reluctant to publish discursive, speculative (but carefully considered) papers.

So let's actively encourage more contributions from

the many excellent amateur field-naturalists in Canada who provide such observational material. Not only would the high scientific standard of *The Canadian Field-Naturalist* not suffer, but it will increasingly motivate field-naturalists to document their particularly significant observations. That will in turn suggest new areas of potential for the study of the diverse and exciting natural environment of Canada. Surely this, and our subsequent ability to manage and protect those resources more effectively, is what we all are ultimately concerned with.

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The following comments are excerpts from the thirteen letters supporting the *status quo.*

In deciding on manuscripts, there is always the problem of striking a balance between relevance and standards on the one hand, and the encouragement of contributors on the other. Hopefully, the development of the journal and of its readers and writers will go hand in hand.

In some respects it belongs to the subscribers and contributors so that making changes is not really fair.

It would be worse than irresponsible after one hundred years of success to consider anything other than to carry on proudly.

Editorial work takes up a great deal of time and is often not openly appreciated by the authors (who often have to rewrite articles to come up to the Editor's standards) or by some of the readers (who do not appreciate that an editor can only have printed articles they receive).

Material published in *The Canadian Field-Naturalist* carries some weight and it has contained numerous articles related to environmental quality or conservation and preservation.

If The Ottawa Field-Naturalists' Club did not sponsor *The Canadian Field-Naturalist,* another group would have to be formed to do so.

I think *The Canadian Field-Naturalist* is an excellent journal serving both the professionals and amateurs alike. Maintain that orientation at all costs.

For convenience I used an institutional corresponding address . . . I would stress, however, that the studies themselves were really "amateur" . . . and not directly related to my "professional" research. Closer inspection would probably reveal a number of examples analogous to mine.

The distinction between an amateur and a professional is unwarranted. I have used an institutional address as a matter of convenience. Most of my submissions to the journal have no relevance to [my professional studies].

There are many members of our local clubs who know very little about nature . . . many are merely people that have a cottage and watch a bird-feeding station . . . the professional biologists have become more and more specialized so that a gap has opened up. *The Canadian Field-Naturalist* serves to close the gap.

Standards must be maintained at all costs. Naturalists in Ontario (and perhaps across Canada) do not under any circumstances have a problem in finding a vehicle for publication of their ideas and observations.

Both amateur and professional naturalists can have their work published and derive enjoyment and information as readers.

In Canada, *The Canadian Field-Naturalist* is the only national journal that publishes important descriptive studies of wild animals and their habitats. I find it an excellent source of information on taxonomy, faunal lists, distribution, and many aspects of natural history.

I am impressed with the scientific quality of *The Canadian Field-Naturalist.* As a Canadian ecologist, I consistently find it to be more useful and relevant than other scientific journals.

Science and natural history have no political boundaries but many Canadians prefer to "publish Canadian" if an outlet of suitable standing exists. In many fields *The Canadian Field-Naturalist* is the only such outlet. . . . No such journal exists in the USA to fill the gap between sterile science and anecdotal recreation and no journal (not highly technical) [exists there] that straddles various branches of biology.

This journal is an important Canadian institution. I had the pleasure of publishing a Note in *The Canadian Field-Naturalist* and felt it provided the official stamp of approval for my observations.

Material published in a respected journal like *The Canadian Field-Naturalist* can lend substantial support as an information base for significant environmental and conservation issues.

Many short notes on occurrences of a single organism draw attention to biological values and recommend preservation.

There isn't any other journal in Canada, maybe not in North America, that fills the same rôle at the same level, whereas there are plenty of alternative outlets

for those who don't wish to meet that level.

So much of human activity is inconsequential when viewed from the vantage point of a century later [but] contributions to the scientific literature are of more lasting value [and] many of these constitute the blocks that knowledge is built upon. The present status of species and of habitats is of most value if we know what changes took place over centuries [because] then we can ask questions and understand the present.

The Canadian Field-Naturalist
— serves a very real need with respect to field biology
— performs an important service to naturalists
— records changes in Canadian natural resources
— documents one or more aspects of Canadian flora and fauna
— publishes descriptive findings [recognizing that there is] still a place in science for descriptions without quantification
— publishes work that is not readily accommodated anywhere else
— has high standards and makes a prestigious service to Natural History
— straddles various branches of biology and has a unique and important rôle in Canadian science and natural history in its present form.

The Canadian Field-Naturalist has a unique and important rôle in Canadian science and natural history. Please don't jeopardize that rôle.

In a country with such a rich natural history, and a human population that appears to be taking an increasing interest in nature and ecology, *The Canadian Field-Naturalist* makes an extremely important contribution. I feel that the publication currently strikes an excellent balance between scientific quality and interest to naturalists. I hope that The Ottawa Field-Naturalists' Club will see fit to continue to make this valuable contribution to Canadian natural history.

Comments on the Editorial *To a Bigot*

(Smith, Lorraine C. 1979. To a Bigot. Canadian Field-Naturalist 93(3): 231.)

Congratulations for the frank and courageous stand you have taken on behalf of field biology and biologists. It needed to be said and by someone who had no particular axe to grind. You said it well, too!

D. A. BOAG
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You are so right, and, unfortunately, the "bigots" have the university administrators on their side.

JERRY M. BASKIN
T. H. Morgan School of Biological Sciences, University of Kentucky, Lexington, Kentucky 40506.

Congratulations and many thanks for another splendid editorial.

STEVE HERMAN
The Evergreen State College, Olympia, Washington 98505

I have just read your oh so necessary editorial. Keep giving it to them. Written in the *field* while conducting *field* ecology studies.

DON GILL
(deceased)
Department of Geography, University of Alberta, Edmonton, Alberta T6G 2E1

Your editorial was superb and heartfelt! I couldn't agree more.

ANNE INNIS DAGG
81 Albert Street, Waterloo, Ontario N2L 3S6

Bravo! for an excellent editorial. You covered almost everything. I would have added only: "As you read this, you will probably accuse us field-biologists of paranoia, but paranoia is a fear of *imagined* persecution."

TOM NUDDS
Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7

As primarily a field-biologist myself, I was a bit surprised to see the editorial. My initial reaction was that editorials might benefit from impartial peer review prior to publication the same as research papers. Perhaps I have been out in the field too long but my impression has been that the old "squirrel-counters vs. the test-tube boys" polarity died over ten years ago and that, for the most part, we have been getting along quite well as members of the same family ever since. I have my fingers crossed that your editorial does not stir up that old mud again. Some of my best friends and colleagues are molecular, laboratory-biologists, some are field-biologists, and some are *both.* I feel that the attitudes expressed in that editorial, regardless of which "side" they come from, are as uncalled-for now as they were several years ago when they were more in vogue.

JAMES W. GRIER
Department of Zoology, North Dakota State University, Fargo, North Dakota 58102

For years some 'field-biologists' have been wailing and whining about the rotten deal that they have received from 'lab-biologists.' On one hand, there have been descriptive studies *ad nauseum* in the lab and in the field, and on the other hand in both settings other biologists have performed innovative experimental research that has enhanced our understanding of many natural phenomena.

An examination of the lists of grants awarded annually by NSERC [Natural Sciences and Engineering Research Council] clearly demonstrates that the idea that 'field-biologists' have been cheated out of good grants by 'lab-biologists' is silly. But, some of those 'field-biologists' often look as though they are working in the laboratory *and* without their leather knickers, perish the thought!

I think that it is healthy for NSERC (or any other granting agency) to ask for some proof of productivity (in the form of refereed publications) before giving away large or small amounts of grant money. There are many 'lab'-biologists and many 'field'-biologists who declare that theirs is an 'active' research program, but who never communicate the information arising from their studies to others. Part of the responsibility of accepting funds for research is communication of the data arising . . .

Probably many 'lab-biologists' not to mention a few 'field-biologists' and even some of the hybrids, regularly scan *The Canadian Field-Naturalist* because they realize that good and useful papers are where you find them. If the trend towards opinionated and pontificating editorials continues, however, I am sure that many will forego any further exposure to *The Canadian Field-Naturalist.*

M. B. FENTON
Department of Biology, Carleton University, Ottawa K1S 5B6

So much of the living natural resources of this vast land remain to be documented that I find it ludicrous to be told to perform experiments if I want grant support.

GEORGE H. LA ROI
Department of Botany, University of Alberta, Edmonton, Alberta T6G 2E1

I marvelled at your editorial; it says quite a bit about dedication in scientific systems. I have several "bigots" in mind who should receive a copy except that they think they're naturalists. One thing might be added: imagine the progress if as much time and money were spent on understanding ecosystems as has been (and will be) spent on laboratory studies.

RICHARD M. ZAMMUTO
Department of Zoology, University of Western Ontario, London, Ontario N6A 5B7

I liked your editorial! I have felt the same way myself so many times. Keep up the good work.

CHARLES JONKEL
School of Forestry, University of Montana, Missoula, Montana 59801

Congratulations on your editorial "To a Bigot." Over the years I have developed a philosophy toward the type of individual to whom your editorial was directed. Surely no serious-minded scientist can deny the value of field biology to human affairs. The field-biologist, in my view, is our first line of defence in the continuing fight to preserve the natural world. Most mammalogists, ornithologists, ichthyologists, entomologists, ecologists, and many other "ologists" are also field-biologists. Their work, especially in systematic biology, is essential to those who wish to work at the molecular or systems levels.

All members of our society who enjoy any aspect of the out-of-doors from fishing to painting, from mushroom-collecting to birding, in large measure are in debt to the work of field-biologists. The legislation enacted concerning wildlife, migratory birds, and endangered species, for example, is based on data gathered by field-biologists.

Thus field biology is so important in our day-to-day affairs that I now regard the bigot as a most unfortunate individual with a limited understanding of biology. Anyone who denies the scientific worth of field biology, or who doesn't appreciate either the necessity of the broad scientific approach that field-biologists must employ or the intellectual discipline required by its practitioners, is to be pitied.

Our success as a species is dependent upon mutual respect and cooperation, particularly among those who have had the advantage of higher education, and especially among scientists. There is no justification or need for, indeed no room for, your "bigot" and his ilk.

W. B. SCOTT
Huntsman Marine Laboratory, Brandy Cove, St. Andrews, New Brunswick E0G 2X0

I congratulate you on a fine editorial in the latest issue of *The Canadian Field-Naturalist.* Yes, unfortunately there are a few scientists who delight in downgrading certain other disciplines. (I suppose some workers are motivated in their research by the belief that they are working in the most important area of science. Perhaps this is necessary in this competitive world?). I am pleased to be in a department where they do not exist. Many of us have heard that publications in *The Canadian Field-Naturalist* are automatically given less weight than articles published in certain other journals by some members of grant selection committees who give no regard to the scientific merit of the articles themselves — they're damned because

of a misguided evaluation of their place of publication. Some scientists have advocated that only people receiving exceptionally large grants should be on grant selection committees, i.e., that people working productively in specialized high-cost research will make the best judges of the research of others.

I especially deplore the situation that apparently some Canadian universities do not consider studies in systematics acceptable as Ph.D. theses (to pick an area other than field ecology that is hard-done-by). This is especially true of vertebrate zoology and we run the risk in Canada of having virtually no vertebrate systematists being produced (I hope everyone is above retorting "so what?"). That this field which synthesizes diverse studies to construct an understanding of historical evolutionary events, attempts to demonstrate evolutionary relationships, and describes the basic units of biology, i.e., species (and can even glorify itself by erecting testable hypotheses) should be so down-graded by computer-modelling biologists, molecular biologists, and the like is a sad commentary on the state of Canadian biology and is surely without sound academic justification. Species are the basic units with which we biologists work; almost any work done that cannot identify a species such that fellow biologists can know exactly what was being worked on is useless. The work of systematists and taxonomists is demanding and can require as much thought process, etc. as any field of biology and it is extremely fundamental to biology.

Although I believe that a minority of physiologists or cell biologists or whatever hold the views that you condemn and that some field-ecologists are also smug in the importance of their work, I am glad that you wrote the article because the former group currently enjoys the more prestigious position. Although I do not advocate that all endeavors within disciplines are equally worthy of pursuit or recognition, as I am sure you do not, one must recognize the importance of field ecology in understanding basic aspects of life. This recognition comes in broadly trained biologists.

J. S. NELSON

Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9

News and Comment

Editor's Report for 1979

The Canadian Field-Naturalist continues to receive in each calendar year a considerable number of manuscripts. After peer review and revision by the authors, a fairly large proportion of these submissions is eventually accepted for publication as indicated in the following table. The figures for accepted manuscripts among those submitted in recent years, however, are not final as some papers may yet be revised, resubmitted, accepted, and published.

Year	Number of manuscripts	
submitted	submitted	accepted
1973	153	117
1974	152	116
1975	167	122
1976	147	92
1977	137	88
1978	149	88
1979	148	

The subject matter of the papers published is very broad. In the following table the total numbers of papers published in specific fields of study in recent years may be compared. The numbers in parentheses are the number of Articles plus the number of Notes.

I believe that the overall quality of the papers we publish is very high and that this is a result of a combination of factors, the most important being the submission of good, well-prepared papers, helpful reviews by referees, editorial direction, and revision by authors. The journal's reputation has grown considerably in recent years and I am particularly proud of it. Fortunately too our financial position appears to be currently sound.

Our new series on *The Biological Flora of Canada* was launched in 1979 with the publication of the first article. This will be a continuing series of papers on the biology and ecological life history of vascular plant species native or well naturalized in the flora of Canada. The format for the series and guidelines for contributing authors were set forth in 1977 by George H. La Roi, Coordinator (Canadian Field-Naturalist 91(3): 269–272). Because the first paper sets the model for all future submissions, we were determined to make this contribution an exceedingly good one. I commend the authors and the Coordinator who worked very hard to produce a paper of first-class quality. Although the final product exceeds the recommended maximum length, there is no doubt in my mind that it is a very complete and concise account and that it will be an excellent model to follow.

The publication of an Annual Annotated List of Range Extensions proposed in 1977 (Canadian Field-Naturalist 91(3): 221–224) has never got off the ground. I think this is particularly unfortunate because there were many good reasons why such a list would be useful and important. In particular I hoped the list would encourage the publication of a greater number of interesting records especially ones by people who had neither the time nor inclination to write research Notes. Certainly there is a definite need to encourage proper documentation of significant range extensions.

Earlier I set forth reasons both for maintaining anecdotal Notes and for the introduction of an Annotated List. These were followed by a statement of a flexible interim approach, a compromise to utilize the advantages of both methods of recording in the literature extensions of species' ranges. I also stated "As with all editorial policy matters, this policy on reporting range extensions will be subjected to frequent reconsideration and will be altered if circumstances warrant."

Although not all authors have rejected the telegraphic style of reporting distributional data, the submissions we have received were ones recording new species for Canada and we believed that these would be more appropriately published as Notes. Editors, of course, can consider only material that is submitted and it appears that many potential authors have rejected our proposed List.

Subject	1976	1977	1978	1979
Birds	43 (6 + 37)	30 (9 + 21)	25 (10 + 15)	34 (7 + 27)
Mammals	33 (12 + 21)	31 (7 + 24)	23 (11 + 12)	18 (7 + 11)
Plants	21 (6 + 15)	16 (9 + 7)	17 (10 + 7)	19 (12 + 7)
Fishes	10 (2 + 8)	10 (0 + 10)	2 (1 + 1)	6 (2 + 4)
Amphibians and Reptiles	7 (1 + 6)	8 (3 + 5)	4 (2 + 2)	5 (2 + 3)
Invertebrates	7 (4 + 3)	4 (1 + 3)	5 (3 + 2)	4 (1 + 3)
Other subjects	4 (3 + 1)	2 (1 + 1)	1 (1 + 0)	1 (1 + 0)
Total	125 (34 + 91)	101 (30 + 71)	77 (38 + 39)	87 (32 + 55)

The Canadian Field-Naturalist has had a long and reputable history of publishing range extensions and these have added considerably to our knowledge of Canadian flora and fauna. Because this journal is the logical publication outlet for these data and has performed this valid function for many years, I wish to see it continued. Therefore, I encourage potential authors to submit anecdotal Notes on range extensions providing that they meet our requirements for publication, i.e., that they contain information that is new, significant, and relevant to Canada.

The awarding of a 1979 Federation of Ontario Naturalists Conservation Award to The Ottawa Field-Naturalists' Club for the continued excellence of *The Canadian Field-Naturalist* was appreciated. In fact the minutes of the club's Council meeting of 14 May 1979 recorded that "a motion commending the staff of *The Canadian Field-Naturalist* for their continuing efforts on our behalf was heartily approved."

Once more I extend my personal thanks to our Associate Editors and to the Assistant to the Editor for their advice and considerable help and time spent on reviewing manuscripts. In particular I thank Anthony J. Erskine who has dealt independently with all the bird papers. I was sorry to lose the services of Associate Editor Robert E. Wrigley who very conscientiously reviewed the many and varied mammal manuscripts that I sent to him and who has served on our Editorial Board for four and a half years. But I am pleased to welcome back W. O. Pruitt, Jr. as an Associate Editor. I also thank the many willing and competent referees who have helped to make the journal one of quality and importance. My hope is that *The Canadian Field-Naturalist* will continue to be widely read and valued both now and in the future.

LORRAINE C. SMITH,
Editor.

The Ottawa Field-Naturalists' Club is pleased to announce the publication of "Autobiography of John Macoun, Canadian Explorer and Naturalist 1831–1920"

In celebration of its 100th Anniversary, The Ottawa Field-Naturalists' Club has published a second edition of John Macoun's autobiography as a tribute to a past president of the Club, an outstanding field-naturalist, and Canadian explorer.

A self-educated botanist who started his career as a farm hand, Macoun was to become one of Canada's most energetic public servants. As Assistant Director and Naturalist to the Geological Survey of Canada, he made collections of plants and animals that formed the basis for the present-day natural history collections of the National Museums of Canada.

New features of the second edition include an introduction prepared by Richard Glover, a map illustrating the routes of five major exploratory expeditions taken by Macoun, editorial notes at the end of each chapter correcting errors in the original text and giving sources of quotations, an annotated list of sources of information about Macoun and publications that contain his reports and record his words, and additional photographs.

Autobiography of John Macoun, Canadian Explorer and Naturalist was first published as a memorial volume by The Ottawa Field-Naturalists' Club in 1922 and is long out of print. The second edition, with its worthwhile additions, will be a valuable asset to many libraries. It is available by mail order from The Ottawa Field-Naturalists' Club, Box 3264, Postal Station C, Ottawa, Ontario, Canada K1Y 4J5. Price (unknown at time of this printing) will be below $15.00. Further details and a brochure are available from the above address.

The Ottawa Field-Naturalists' Club Memorial Fund

The Ottawa Field-Naturalists' Club has established a memorial fund in memory of W. K. W. Baldwin and Father Farrell Banim, two prominent Honorary Members of the Club who recently passed away.

Bill Baldwin was a founder in 1948 of the Macoun Club, an organization of young naturalists cosponsored by The Ottawa Field-Naturalists' Club and the National Museum of Natural Sciences. In light of his interest and work with young naturalists, donations made in his memory will go towards a special section of The Ottawa Field-Naturalists' Memorial Fund to be known as the Bill Baldwin Memorial Fund and will be used for Macoun Club projects.

Those making donations in memory of Father Banim could specify which of The Ottawa Field-Naturalists' Club activities, such as the Macoun Club or bird feeders, they would like the money to be put towards. If no specification is made, it will be used to support future Club projects.

All donations should be sent to The Ottawa Field-Naturalists' Club, Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5. Cheques should be made payable to The Ottawa Field-Naturalists' Club. Receipts will be issued for income tax purposes.

Book Reviews

Zoology

Biology of Fishes

By Carl E. Bond. 1979. Saunders, New York, Toronto. vii + 514 pp., illus. $22.75.

Biology of fishes is intended by author Bond to be a beginning book designed to provide an appreciation of the diversity and importance of fishes — a book intended to be an introduction for the general reader and for the college student with every effort made to keep coverage simple. This intent is admirably met. The book is generally well written in good narrative style and in easy-to-understand language. It is not intended to be a detailed reference or textbook. There are very few literature citations; references used in compiling the text are given at the end of certain chapters.

The book consists of three sections, 17 chapters, a relatively short glossary of 81 ecological, physiological, morphological, etc. terms, and a 36-page index. The figures are large and adequate for their intent.

Section One, Introduction and Structure, briefly explores fish diversity and reviews external and internal anatomy; concise comparative descriptions of the major fish groups (class level) are given. There is sometimes too much reliance on name differences without giving the reader an understanding of the biological difference. For example, the terms bulbus arteriosus, conus arteriosus, opisthonephros, and mesonephros are given but not clearly explained as might be expected in an introductory book. One is told that the nuchal region is behind the occiput but the occiput is not defined. Section Two, Relationships and Diversification of Fishes, reviews the diversity and relationships of major fish groups. This descriptive section, although a good elementary review, does not allude to differing methodologies or philosophies of classification (phenetic, cladistic, and synthetic or evolutionary approaches). This is unfortunate, even for an elementary book, when present-day ichthyology is so alive with real or imagined differences of opinion. Several years may be expected to lapse between writing parts of the text and the publication of the book but it is unfortunate that the references for this section effectively go up only to 1973 (two "competitive" books are cited: Lagler et al.'s 1977 *Ichthyology* and Norman and Greenwood's 1975 *A history of fishes*; but no other systematic works after 1973 are cited other than the 1974 translation of Lindberg's 1971 work). Section Three, Biology and Special Topics, discusses a wide variety of subjects ranging from physiology to management. This section will perhaps interest readers of *The Canadian Field-Naturalist* the most. The chapters on color, light, sound, and electricity and sensory function are especially interesting.

Over-generalization, omissions, inconsistencies, etc., can inevitably be found in any book and reference to some of them here by no means is intended to distract from the book's usefulness. Generalizations are often necessary and Bond's book keeps them within reason. In the half-truths, however, Bond states that tubesnouts lay eggs in ascidians; this has been reported in only one of the two species (the Japanese *Aulichthys* by K. Uchida, not the North American *Aulorhynchus* which is described by C. Limbaugh as building a stickleback-like nest in kelp). The mooneyes are described as being in eastern North America and although that is true it is a poor generalization since both species of the family extend westward into central Alberta and, as known at least since 1959, one into northern British Columbia. The anal fin is said to be modified into a gonopodium in the poeciliid *Tomeurus* but this is true for the whole family. In discussing aerial vision in *Dialommus* the presence and advantage of a flattened corneal surface as discussed by J. B. Graham and R. H. Rosenblatt in *Science* for 1970 is omitted. *Cheimarrichthys* is inconsistently put in its own family (conventional practice) and placed in Mugiloididae (advocated by R. M. McDowall). The book anticipates some very recent findings such as stating that pegasiforms are perhaps related to gasterosteiforms (suggested in *Copeia* 1978 by T. W. Pietsch) and showing that the Heterostraci extend into the Cambrian (reported in *Science* 1978 by J. Repetski). (The antiquity of jawed fishes, by the way, is pushed back further than previously known with the recent report in *Nature* by D. A. T. Harper of Ordovician evidence of acanthodians brought to my attention by my paleoichthyologist colleague M. V. H. Wilson.)

I recommend *Biology of fishes* to all biologists as providing a sound introduction into the biology of those heterogenous animals which comprise about one-half of all species of vertebrates. I applaud Bond for his contribution.

Joseph S. Nelson

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Endangered Birds: management techniques for preserving threatened species

Edited by Stanley A. Temple. 1978. University of Wisconsin Press, Madison. xxiii + 466 pp., illus. U.S. $9.50

In recent years the ornithological literature has been flooded with books and papers on endangered species. Most of these are crisis oriented. This book differs from the others in that it covers a wide range of species and focuses primarily on techniques for managing populations of endangered birds. The contents consist of papers given at a symposium, by 53 authors, in August 1977 at Madison.

The papers are of high quality throughout. The style ranges from almost "popular" articles (e.g., Zeleny), to progress reports, to highly technical works, and the 51 chapters are grouped into 10 parts. Part I contains three chapters which serve as a background introduction to the concept of managing endangered birds. Part II, "Increasing reproductive effort and success by reducing nest-site limitations," consists of a review by Noel F. R. Snyder, followed by five chapters documenting case histories. Part III, "Alleviating problems of competition, predation, parasitism and disease" consists of a review chapter by J. A. Jackson and chapters on brood parasitism of Brown-headed Cowbirds on Kirtland's Warbler (H. F. Mayfield), Bermuda Petrels and burrow competitors, chiefly tropicbirds (D. B. Wingate), Red-cockaded Woodpeckers and cavity competitors (Jackson), Puerto Rican Parrots and Pearly-eyed Thrashers (N. F. R. Snyder and J. D. Taapken), and controlling introduced predators and competitors on islands (D. V. Merton). Part IV, "Supplemental feeding and manipulation of feeding ecology," consists of a review by G. W. Archibald, and chapters on feeding California Condors (S. R. Wilbur), cranes (Archibald), White-tailed Sea Eagles (B. Helander), and Japanese Crested Ibises (Y. Yamashina). Part V, "Manipulating aspects of nesting biology," consists of a review by T. J. Cade, and chapters on Osprey egg and nestling transfers by P. R. Spitzer, fostering and cross-fostering raptors (R. W. Fyfe, H. Armbruster, U. Banasch, and L. J. Beaver), sibling aggression and cross-fostering of eagles (B.-U. Meyburg), and cross-fostering Whooping Cranes to Sandhill Crane parents (R. C. Drewien and E. G. Bizeau). The work by Fyfe et al. will be of particular interest to Canadian readers, as most took place in Alberta. Also of special interest for Canadian content is the chapter on Whooping Cranes, as the program involves Ernie Kuyt, who collects the eggs in Wood Buffalo National Park. The idea of using Sandhill Cranes in this manner originated from Fred G. Bard, former director of Saskatchewan's provincial museum. Part VI, "Captive breeding of endangered birds," consists of a review by W. G. Conway, and chapters on captive breeding of Whooping Cranes (C. B. Kepler), waterfowl (J. Kear), Peregrine Falcons (T. J. Cade and R. W. Fyfe), and *Amazona* parrots (H. A. J. Nichols). Conway considers this technique as a last resort in preserving species, but also points out the tremendous potential of zoos in advancing public education of the problems of rare species.

Part VII, "Genetic aspects of dwindling bird populations," consists of a review by T. E. Lovejoy, followed by a mathematical chapter by C. Denniston, a discussion by K. W. Corbin on genetic diversity, "The Noah's Ark problem" by U. S. Seal, and a discussion of fitness of offspring from captive populations by A. J. Berger.

In Part VIII, "Reintroducing endangered birds to the wild," Richard W. Fyfe of the Canadian Wildlife Service points out in a review chapter that no examples are yet available of self-sustaining wild populations of birds resulting from reintroductions into the original habitat. His own research on Peregrine Falcons may in time provide such an example. Fyfe's review is followed by four chapters on reintroductions involving captive breeding programs and three chapters not involving captive programs.

Part IX is the logical follow-up to the previous parts. R. L. Plunkett in his review of "Integrated approaches to management of endangered birds," outlines the history of approaches, lists their key elements, and briefly outlines several examples, chiefly from North America. Anne La Bastille expands on one example, concerning the flightless Giant Pied-billed Grebe of Lake Atitlan in the next chapter. The following five chapters are broader in scope, concerning the use of nest record card data (D. A. McCrimmon, Jr. and J. Bart), population modeling (R. S. Miller), land management (R. R. Olendorff and W. D. Zeedyk), the United States recovery plan approach to endangered species (D. B. Marshall), and manipulating behavior patterns (S. A. Temple).

Ian C. T. Nisbet's concluding remarks constitute the only chapter in Part X. I agree with Nisbet that the technical papers in the symposium were excellent, but that the general focus is too narrow. This is not a fault of the authors, but rather a statement of the "state of the art." This volume contains many examples of excellent studies, and heartening examples of new hope for seemingly doomed species. However, until greater efforts are done to protect habitats and ecosystems, these officially endangered species really represent only the tip of the iceberg.

My only criticism of this volume involves the 31 black-and-white plates in the center of the book. These are generally good photographs, the captions

are informative, and in most cases refer to the chapter to which they are appropriate; however, the plates are never in turn mentioned in the chapters, so that a reader seeking information from one or a few chapters may never realize that appropriate photographs are also present.

In general, this is an excellent book which should serve as a landmark state-of-the-art volume. It should be in the library of every biologist concerned about vanishing species, and especially in the libraries of zoos. Given the nature of the subject matter, one can only hope that it helps serve to out-date itself quickly.

MARTIN K. MCNICHOLL

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Ducks, Geese, and Swans of the World

By Paul A. Johnsgard. 1978. University of Nebraska Press, Lincoln. 404 pp., illus. US$35.

An undertaking of this magnitude, involving all species of the Family Anatidae, is difficult at best. Jean Delacour used four volumes to cover the same subject in *The waterfowl of the world* (1954–64). Although this is not in the same degree of detail as the latter work, Paul Johnsgard has succeeded in producing a book of considerable value. Perhaps the most impressive feature is the tremendous amount of information that has been compressed into a single volume.

The format is a series of 148 individual accounts of species of waterfowl presented by tribe. The text includes sections on subspecies and range, measurements and weights, identification, habitat and foods, social behavior, reproductive biology, status, relationships, and suggested readings. Included throughout are line drawings and maps which serve to break up the text and provide a pleasing presentation. Color plates are poorly reproduced and represent only 28 species; one wonders why they were included at all.

The text is generally well researched and uses data from Russian and Chinese papers not included in other recent works (e.g., *Wild geese* by M. A. Ogilvie. 1978. Buteo Books). Much meaningful information has been excluded, but in order to achieve the single volume this was a necessity. Perhaps the major criticism that can be made is the unequal treatment given to various topics. Behavior is dealt with at considerable length whereas discussion of habitat is limited at best. Brood habitat and molting areas are omitted altogether; however, a large amount of general information is presented and the suggested readings provide a source of further study if desired.

Maps are small and serve only to indicate areas of the world where a species breeds and winters. Some errors were made: Steller's Eider does not breed on the Yukon north slope, Ross' Goose does not breed on Banks Island and winters also on the coast of the Gulf of Mexico, and a world map was included for the Ruddy Duck which breeds only in the Americas.

This book will be a welcome addition to the library of waterfowl enthusiasts, particularly those who do not work in this field. It would be of value for anyone considering visiting other continents on bird-watching expeditions.

IAN D. THOMPSON

P.O. Box 895, Cochrane, Ontario P0L 1C0

Migratory Game Bird Hunters and Hunting in Canada

Edited by H. Boyd and G. H. Finney. 1978. Canadian Wildlife Service Report Series Number 43. Supply and Services Canada, Ottawa. 125 pp., illus. $7.50 in Canada; $9 elsewhere.

This volume represents the beginning of a much needed systematic approach to managing migratory game birds in Canada, and is a must for professional waterfowl managers and interested biologists. It is a book about the Canadian national migratory game bird surveys, which describes the creation and development of the program and summarizes some of the major results to date. Its aim is ". . . to provide a reliable account of the basic facts that have emerged from the first decade of the national migratory game bird surveys, and to suggest how we hope to develop effective probes for finding out not only what is happening but why, and to work towards a genuine craft of migratory game bird management as the need grows."

The book begins with an erudite description of the survey methods used to gather the data, which are designed to allow for the identification of specific problems at the local and regional levels. This is followed by a section on the migratory game bird hunter.

Knowledge of the hunter, his needs and preferences, is of great importance because it assists biologists in the implementation of unique management programs.

The third section deals with the distribution of waterfowl kill in Canada. Of particular interest here is the use of maps, which provide a useful index of harvest on a temporal and geographical basis. Section 4 contains papers concerned with specific studies drawn from the data collection program. In these studies (about the Black Duck, the Gadwall and American Wigeon, and the Sandhill Crane) the authors do not simply report their findings, but have endeavored to adapt the data to a form suitable for use as a management tool.

Although these studies uncovered inherent difficulties with the program, they represent the beginning of a potentially successful migratory game bird management program. For example, the investigations on the Black Duck, and the Gadwall and American Wigeon, were, in part, designed to examine the possibility of using species composition surveys to provide useful measurement of annual productivity and population size. Unfortunately the studies have yielded primarily negative results. But in H. Boyd's words, ". . . it is of course far too early to abandon such attempts, both because the run of years is very short and because the methods of analyzing the data are still in their infancy."

Alternative roles of the information and possible future uses of this method of data collection are also reviewed, based on experiences to date.

It is obvious from the book that successful future management of the migratory game birds and their hunters will not be an easy task. But now that Canadian biologists possess an easy and relatively inexpensive method of collecting a great deal of valuable data on a broad geographical scale, the key to success seems dependent upon continued enthusiasm and cooperation between governments, biologists, and hunters.

PAUL A. GRAY

Hough, Stansbury, and Michalski Ltd., Suite 409, 1265 Arthur Street East, Thunder Bay, Ontario P7E 6E7

BOTANY

Eastern North America's Wildflowers

By Louis C. Linn. 1978. Dutton, New York and Clarke Irwin, Toronto and Vancouver. 277 pp., illus. $12.95.

The core of this book is a collection of reproductions of 373 watercolors of some of the showy wildflowers and weeds found in northeastern United States, over half of which also occur in Canada. These illustrations, although they are for the most part recognizable to species are certainly not "botanically perfect in every detail" nor do they "reveal, with far more clarity than a color photograph, every distinctive aspect of each flower" as advertised on the jacket. They are, in fact, pen-and-ink sketches which have been rather badly filled in with color.

The text which accompanies the illustrations was prepared by Ruth Linn, wife of the artist, twenty-five years after his death. She has contributed a color key for identification, short descriptions of the 373 species, notes on habitat, range, frequency, and time of flowering. All are arranged in an approximate order of flowering from spring to fall. There is a chapter on flower families, which gives descriptions of the 69 families represented in the book, illustrations of flower and leaf types, a glossary and an index.

This book, which is touted as "One of the most beautiful field guides ever published . . .", leaves much to be desired. There are far better books that can help identify our native and introduced flora.

WILLIAM J. CODY

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NEW TITLES

Zoology

Arthropod phylogeny. 1979. Edited by A. P. Gupta. Van Nostrand Reinhold, New York. xx + 762 pp., illus. US $32.50.

The behavior and ecology of wolves. 1978. Edited by E. Klinghammer. Garland STPM Press, New York. 300 pp. US $27.50.

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Mailing date of previous issue 13 November 1979.

Editor's Correction of Terminology

Reference: Davies, Ronald W. 1979. Dispersion of freshwater leeches (Hirudinoidea) to Anticosti Island, Quebec. Canadian Field-Naturalist 93(3): 310–313.

Dictionaries generally make no clear-cut distinction between dispersal and dispersion. But the common usage in ecology is for "dispersal" to refer to the act or process of dispersing, and for "dispersion" to describe the pattern of spatial distribution resulting from dispersal. Therefore, the word "dispersal" should replace "dispersion" in the title and throughout the text of this paper.

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Their Excellencies the Governor General and Mrs. Edward Schreyer

The objectives of this Club shall be to promote the appreciation, preservation and conservation of Canada's natural heritage; to encourage investigation and publish the results of research in all fields of natural history and to diffuse information on these fields as widely as possible; to support and cooperate with organizations engaged in preserving, maintaining or restoring environments of high quality for living things.

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Cover: Gyrfalcon with ground squirrel prey photographed by E. Kuyt in the Thelon River area, Northwest Territories on 2 August 1961. See article on page 121.

The Canadian Field-Naturalist

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A Naturalist's Approach to Biology[1]

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In case some of the younger members are wondering, I hasten to assure them that, although I am what our paternalistic governments glibly call a senior citizen, I am *not* a charter member of the club and so have no special qualifications for addressing this centennial dinner. I am a bit hazy about how or when I joined the club, somewhere around the end of World War II. Probably Ibra Conners, whom I was then assisting, had a hand in it, for he and several other members of the old Botany Division were active in the club's operations. At about that time, also, I was discovering that different birds had differently shaped wings, with significant aerodynamic implications; and to explain this diversity I had to identify the birds and find out how they lived. So I started going out on the Saturday afternoon excursions, being very dubious about identifying anything but robins and male House Sparrows. About two years later, still a mere neophyte, I found myself pushed into leading many of the bird walks. You see, I was a *professional*. That leads me into my topic!

What are the distinctions between natural history and biology? And what are the distinctions between the professional and the amateur in natural history and biology? You may recall the episode in the French National Assembly when a deputy was speaking in favor of equal pay for women. "After all," he said, "women are not very different from men." A gallant deputy immediately leapt to his feet, hand over heart, and cried "Vive la différence!" Although I agree heartily with him, I hold the opposite view upon natural history and biology and would cry, "Vive l'unité."

Despite somewhat contrasting goals and viewpoints the amateur naturalist and professional biologist depend upon each other. The more natural history and biology are integrated the better for both. We still have far too few competent all-round naturalists in Canada. If someone needs viable seed of an inconspicuous grass that grows 3000 km from his base, there should be an informed naturalist in the right area who can unfailingly collect seed and a voucher of it for him. Is that too much to ask? It would be routine in some countries.

What holds our beginners back? More than anything I think it is sheer fright. Because we in Canada lack a cultural tradition in natural history, many potentially capable naturalists give up at the thought of using a manual in which the plants have Latin names. To communicate with such people the botanist must make up common names for hundreds of inconspicuous plants that lack them, usually by translating, or occasionally mistranslating, the Latin names. Why should learning the international names be any harder for us than for the Japanese, Russians, Swedes, Germans, Swiss, Poles, Czechs and others, to whom natural history is a way of life? Once when we had two of our Czech families home for Christmas the talk turned one evening to mushroom poisoning. Jiri Nor, a very capable engineer but with no training in biology, pulled Walt Groves' book out of the bookcase and was browsing through the amanitas to see what we had, with of course only the Latin names available. Suddenly he pointed out an additional character by which he distinguished two of the species in Czechoslovakia. I suppose I looked stunned, for his friend laughed and said he had

[1]Prepared for The Ottawa Field-Naturalists' Club centennial banquet of 19 May 1979 but unfortunately, owing to illness, not presented.

been studying them since childhood. Well, there is no reason why we should not, like so many Europeans, bring a sense of dedication to our hobbies. Why, similarly, should learning to use keys be beyond people who can learn, say bookkeeping, weaving, or the rules of a game? Of course it takes some effort, but so does any worthwhile achievement.

Plenty of people have risen to eminence in fields for which they had no formal training. Discussing the amateur in ornithology, Harold Mayfield mentions that Ridgway and Chapman had no university training in biology. To them we can add Taverner, who trained, I seem to recollect, in architecture. Unfettered by custom he innovated by recording specimen weights and he often spread one wing of a study skin, both very desirable customs. Botanists are familiar with plants named by Fernald and Griscom; Ludlow Griscom later became one of the most revered figures in American ornithology.

There is really little or nothing to limit the achievements of the diligent amateur. He may occasionally need help from a professional; but there can be few professionals who do not similarly owe a debt of gratitude to some of their colleagues. The amateur may make occasional mistakes; but the only professionals who have never done so are those who seldom if ever commit themselves to a firm decision on anything.

Apart from an orderly approach, needed for any occupation, the main qualification for the amateur, as for the professional, is enthusiasm for the unknown and appreciation of it. Albert Einstein, whose centennial we also celebrate this year, once said "The most beautiful experience we can have is the mysterious . . . Whoever can no longer wonder, no longer marvel, is as good as dead, and his eyes are dimmed." Of a physicist Einstein once said he "couldn't understand how anybody could know so much and understand so little." (You may recall that Pooh made a similar remark about Rabbit.) How well that expresses success in natural history: to interpret what we see, and not merely to record data. And how exciting it is when we achieve an understanding of some unexplained character of an organism. Understanding does a lot more than provide intellectual satisfaction, however. When we understand the function of a character we are warned that, because it is useful, it may have evolved more than once, and organisms that possess it are not necessarily related.

Some disciplines do need costly and complex equipment, but many do not. A visitor once asked Einstein if he might see his laboratory. Einstein obligingly reached into his pocket and proffered his fountain pen. It is the mind (including the imagination) behind the pen that counts.

If the naturalist with broad interests keeps assembling the conclusions from his observations, he will often find he is well into a piece of formal biological research. He need not be ashamed. Many biologists are eminently respectable. It is only the rabid specialist, like a biochemist who does not think of his materials as being derived from living evolving organisms, to whom the distinction between biology and natural history seems absolute. The blending of the two fields is not only inevitable; it is highly desirable, for it forces us to accept multidisciplinary studies, to which we shall return in a moment.

We cannot draw a sharp line between amateur and professional studies of either of these fields. If a professional business man — doctor, engineer, or chartered accountant — studies birds he does so as an amateur, although he brings a disciplined mind to bear on his hobby. But if a professional mycologist, with no training in ornithology, studies birds he may find his amateur status questioned. After all he probably dissected a frog in elementary zoology. If he then goes and studies flowering plants he has had it. He's a Pro, unless he can convince his critics that Robert Whittaker and Lynn Margulis are right, and fungi are not plants but form a separate kingdom. It is all very confusing and the inquisitive naturalist may say, as Christopher Robin once did: "I'm feeling rather funny and I don't know *what* I am."

A correspondent in *Science* stated some years ago that it had been impossible for anyone in the last century to encompass more than one discipline. Perhaps he was trying to excuse his own mental myopia. If he had ventured to peer over the edge of his rut, I wonder what he would have made of D'Arcy Wentworth Thompson, that renowned classicist, mathematician, and zoologist.

The mushrooming of most fields of biology is making it increasingly difficult to keep up with all the literature and techniques of a major discipline. We hear that specialization and the team approach are the answer. Although this combination can yield good results, it is often imperfect. Complete specialization is neither necessary nor desirable.

We must usually specialize to some extent in our main discipline; but that is no reason for us to ignore the rest of the living world. We see too much of this sort of thing in North America: ecologists who fail to distinguish between superficially similar plants and seem undismayed at the chaos wrought by their ignorance; systematists ignorant of all but one or two families of organisms; and others who erect phylogenies of organisms with no useful fossil record, without bothering to learn, from vertebrate paleontology, how evolution actually operates. Among some of my fellow mycologists in North America my own diverse interests have been viewed with some suspicion, as if it were traitorous to look at any organisms but fungi. On visits to Europe, on the contrary, I have found the opposite view: that fungi should not be studied out of context with their environment. Several European mycologists have been deeply involved with flowering plants, such as Petrak doing the first monograph of North American thistles, Nannfeldt revising the northern blue-grasses, and Kukkonen studying the evolution of the sedges.

The specialist has been unkindly defined as someone who learns more and more about less and less until he finally knows all about nothing. More seriously we can say that he accumulates data that he fails to understand. The team approach is often necessary but is really a partial solution. At its worst the team of specialists is like the blind men trying to describe an elephant. They likened it respectively to a wall, a tree, a snake, a spear, a fan, and a rope. In the study of a complex biological system someone must be adventurous enough to move all round the elephant; and nearly all biological systems *are* complex, far more so than many physical or chemical systems.

Of course a team is needed when several complex techniques must be used; but, unless some team members can see the problem from other viewpoints than their own, crucial points can be overlooked and progress is slow and uncertain. Over 30 years ago Marston Bates wrote an account of jungle yellow fever in South America, in which he showed that the spectacular success of the project was largely owing to everyone in the group working in at least one discipline in addition to his own. Thus they were quickly able to see the complete picture of the parasite, its vectors, the forest workers, and the natural hosts. Not long afterwards some of us, involved in the ecology of the northern biting flies, reached a similar conclusion: it paid us to mind each others' business.

Natural mechanisms that aid in such important processes as dispersal of non-motile plants and fungi often stare us in the face for years, while we stare uncomprehendingly back at them. The elucidation of the splash-cup mechanism that disperses the little peridioles (or "eggs") of the bird's-nest fungi took many years of observation by many naturalists before it was finally worked out by Harold Brodie and Reginald Buller. The story is told in some detail in Brodie's delightful book *The Bird's Nest Fungi*, but the mechanism was first described by him in a paper in *Canadian Journal of Botany* in 1951. With their eyes finally opened, several people soon showed the same device in various bryophytes and flowering plants. I demonstrated it in 1952 in *Chrysosplenium* (Golden Saxifrage) and *Mitella* (mitrewort), and sent a note to *Science*, which in those days still deigned to recognize organismal biology as a scientific field. I thought that *Tiarella*, which includes our Foam-flower and is closely related to *Mitella*, was more primitive because it lacked the splash-cup, but to keep my note as short as possible I fortunately omitted the reference to *Tiarella*. The note appeared in March 1953; and less than three months later Jim Calder and I were standing one drizzly day, taking our first look at the British Columbia coast forest at Bridal Falls. As I looked at the capsules of *Tiarella trifoliata* I saw the odd one flicker as a drip hit it. Bending down and depressing the long projecting lower valve of the capsule, I found that a seed usually rolled down it, ready to be flipped out as the valve snapped up on release. Objects are ridiculous only when we do not understand them. As I looked, the comic

capsule was suddenly transformed into a superbly engineered dispersal system. At about the same time Harold Brodie was elucidating a similar device in *Salvia* capsules and other plant organs; and he later christened them collectively the springboard mechanism. They say that great minds think alike; but we see that even lesser minds may do so if something happens to unclog them. How *can* we unclog our minds? It seems to me that we have to abandon our prejudices and use our imaginations. In such studies the amateur naturalist, or the professional biologist working outside his field of training and effectively an amateur, has an advantage because he has not been brainwashed by the dogmatic statements copied from textbook to textbook. The working out of the springboard mechanism was achieved by professional mycologists who were essentially amateur botanists.

Well, with the repeated evolution of springboards and splash-cups qualitatively established, surely it was time for a quantitative picture of the power of a falling drop. Obviously a large drop packs a bigger punch than a small one, but how much bigger? The problem was not as simple as it may seem, for meteorologists are mainly concerned with the gentle rain that droppeth from heaven — and droppeth generally in quite small drops at that. What we are concerned with is the acceleration of drops, large and small, in the first few metres of fall. I set it aside, being busy with other work, until Brodie wrote *The Bird's Nest Fungi*, which goaded me into action. In our Agrometeorology section I found papers giving data on terminal velocities and drag coefficients for drops of various sizes. This information still did me little good, as my aerodynamics was moribund and my calculus stone dead. Well, always call for help when you are stuck. Henry Hayhoe, a mathematician in Agrometeorology, came to my rescue by deriving an equation that would give the velocity of a drop of given size at a given distance of fall. The results were startling, to say the least. Rain drops are usually about 2 mm diameter or less, those as large as 3 mm being rare because they sooner or later break up. But drops falling a few metres from vegetation are usually 4 to 4.5 mm diameter. We find that a 4-mm drop, after falling only 25 cm, already has the momentum (i.e., mass by velocity) of a 2.5-mm drop at terminal velocity and more than twice that of a 2-mm drop. A 4.5-mm drop after 25 cm has the momentum of a 3-mm drop at terminal velocity. These results are very revealing. They indicate that, although splash cups and springboards may occasionally be operated by large rain drops, it is under canopies, where the drops are always large, that selection for the mechanism is likely to occur. We see also that we do not need a tall tree canopy. A shrub canopy of less than a metre is ample. Now I finally saw why *Chrysosplenium rosendahlii* flourished in marshes on Somerset Island under a canopy of nodding grass and sedge inflorescences that provided less than half a metre of fall. Here, too, is the explanation of why Harold Brodie was able to find the bird's nest fungus *Cyathus olla* under shrubs in the Peruvian desert where the only precipitation is fog or dew. At that site it seems safe to assume that a desert mouse emerges in the cool dusk to collect leaves and twigs, and incidentally carries and eventually eats *Cyathus* peridioles. These figures also have considerable import to plant pathologists, for various pathogenic fungi and bacteria are water-dispersed.

Twenty-seven years after the splash-cup mechanism was described we finally could compare the momentum of drops of different sizes and lengths of fall, although we still do not know what percentage of this momentum is transmitted to the seeds or other missiles. If that seems slow progress, just consider that naturalists had been observing bird's nest fungi for the preceding 350 years without much success.

The solution of such problems clearly needs a combination of observation, experiment, and imagination.

Sometimes a naturalist can empirically solve a problem too complex to treat readily by orthodox means. In high-arctic deserts most of the individual plants are extremely small; they often cover much less than one percent of the ground; and they occur randomly rather than in regular associations, because there is no appreciable competition between species. Even if it were feasible to carry the equipment and a power supply about in such terrain, an enormous amount of sampling would be needed for a reasonably accurate measure of biomass productivity. In the course of his other studies, however, a

field-biologist who regularly patrols some 20 to 40 km^2 can easily run a breeding bird census. He can locate almost every nest except those of Snow Buntings and Hoary Redpolls, which nest mostly in boulder talus; and for them he can count singing males per unit length of talus. As the birds depend ultimately on plant productivity, their densities allow a meaningful comparison with low-arctic closed tundra.

No organisms exist in complete isolation. Plants depend on bacteria, fungi, or even blue-green algae for their nitrogen supply. Most plants must have symbiotic mycorrhizal fungi for good growth. Saprophytic fungi speed the decay of dead plants; and parasitic fungi attack living plants. Their relationships with various animals are similarly complex.

Despite an immense amount of skilled work we still do not fully understand the relationship of obligate parasites, such as the rusts, with their host plants. The broad outline of the process of co-evolution of rusts and their hosts, however, has become increasingly clear in recent years, but only through a consideration of various aspects of both hosts and parasites, and in natural populations little affected by human activities. We now know that a rust in its evolutionary youth, when it is genetically flexible, may occasionally jump to an unrelated but ecologically associated plant species that is also young and genetically flexible, and evolve into a new rust species. Only a good understanding of the geography, ecology, and systematics of the organisms involved could allow the interpretation of this complex relationship. It is definitely not a job for the desk-bound specialist, but rather for the field-naturalist.

After I retired I took more than a year to study adaptive changes that occur in rust fungi in response to various environmental stimuli, including seasonal aridity, spore-eating insects, host tissue structure, dispersal problems, or the perpetually saturated atmosphere of tropical rain forest. I was then able to rationalize the classification of the rusts, abandoning various pet characters that we now see to have evolved repeatedly in response to particular evolutionary pressures. Thus when I was asked to review the whole topic of using data from parasitic fungi as aids in higher plnt classification (a path bestrewn with pitfalls for the unwary specialist), I was able to bring to it a heightened understanding, especially of the rust fungi. Consequently the last year and a half, although often hectic, and involving lots of healthful exercise (my attic groove being three flights above the library stacks), has also been decidedly productive. Lineages established in the rusts have given us much firmer information on the relative ages of origin of various genera, tribes, or families of plants than was previously possible; and relative age is fundamental to the phylogenetic classifications at which we aim. There is no future to deriving family B from family A, when the parasite data emphatically show A to be younger than B. A few of these conclusions will scandalize some of my phanerogamist colleagues. Otherwise my only regret over this multidisciplinary undertaking is that I have had to correct several enthusiastic taxonomic deductions by others in this field that turn out to be based on misdetermined plants, misdetermined parasites, or false ideas of close relationships between fungi.

Vegetation Survey of a James Bay Coastal Marsh

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Surface elevation changes, soil and surface water chloride ion levels, and vascular plant species frequency distributions were examined along two transects on a western James Bay coastal marsh. Mean inland slope for the marsh area was 0.84 $m.km^{-1}$. This value was used in conjunction with published estimates of the rate of land emergence on western James Bay to calculate an interval of 106–142 yr for the age of the marsh and an annual rate of 10–15 m for the seaward advancement of the vegetation. Chloride ion levels were generally low and representative of a brackish marsh regime rather than a salt marsh regime. The main intertidal colonizers were *Potamogeton filiformis*, *Eleocharis* spp., and *Hippuris tetraphylla* while the vicinity of mean daily high tide was dominated by *Puccinellia phryganodes*. Several taxa above the intertidal area were discontinuously distributed occurring either on successive ridges or in successive interridges. The principle ridge taxa were *Triglochin maritima*, *Puccinellia lucida*, *Puccinellia phryganodes*, *Calamagrostis* ssp., *Carex paleacea*, *Juncus balticus*, and *Potentilla anserina*, and *Carex mackenziei* was the predominant interridge taxon. Floristically, the Kapiskau marsh bears a close resemblance to coastal marshes in Fennoscandia particularly on the brackish Baltic Sea.

Key Words: aquatic plants, James Bay, coastal marsh, vegetation, brackish water environment, surveys, community composition.

The western James Bay coastal marshes extend nearly continuously from southern James Bay to the vicinity of Churchill, Manitoba on the west coast of Hudson Bay. The marshes are of prime importance to northern avifauna not only in terms of the extensive marshland habitats provided but also in terms of the number of ornithological types that have originated in this area (Manning 1952). Yet, in spite of their extent and importance, only two ecological studies of the coastal marshes have been published. Pielou and Routledge (1976) in a study of latitudinal gradients in salt marsh vegetation examined vascular plant zonation patterns on the estuaries of the Attawapiskat and Moose rivers in James Bay as part of a transect extending from Halifax, Nova Scotia to Churchill, Manitoba, and Glooschenko (1978) investigated above-ground biomass of vascular plants on the coastal marsh at North Point. In addition, a general floristic treatment of the western James Bay region was produced by Dutilly et al. (1954). There have been related studies on coastal marsh zonation patterns at East Pen Island in southwestern Hudson Bay (Kershaw 1976) and in the Canadian Arctic (Jefferies 1977).

In light of the increasing interest in the natural resources of northern Ontario particularly in hydroelectric potentials of the major river systems flowing into James Bay, this deficiency of basic ecological information prompted the Ontario Ministry of Natural Resources to initiate a series of vegetational studies on the coastal marshes. The series began in 1972 at Shipsands Island[1] in the Moose River estuary and continued in subsequent years at Puskwuche Point,[2] Shagokow,[3] and Bouy's Bluff.[4] The final study of the series was carried out in July and August of 1977 near the mouth of the Kapiskau River (52°46′N, 81°54′W) and the results are reported here.

Study Area

The location and layout of the study site are shown in Figure 1. The mouth of the Kapiskau River follows a slightly sinuous single channel course through the coastal marsh and intertidal flats. Compared to the large multi-channel rivers that enter western James Bay, such as the Albany and the Moose, the Kapiskau River is quite small. The latter has an estimated flow rate of 62 $m^3 \cdot s^{-1}$ whereas the former two rivers have

[1]Riley, J. and C. Moore. 1973. Preliminary vegetation survey of Shipsands Island, waterfowl sanctuary. Ontario Ministry of Natural Resources, Forest Research Branch, Toronto. 44 pp.

[2]McKay, S. M. and M. D. Arthur. 1975. Vegetation survey of Shipsands Island and Puskwuche Point, southwestern James Bay. Ontario Ministry of Natural Resources, Policy Research Branch. 97 pp.

[3]Arthur, M. D. and I. F. Marshall. 1976. Vegetation survey, nine kilometers northwest of North Point, southwestern James Bay, summer of 1975. Ontario Ministry of Natural Resources, Office of Science Advisor. 39 pp.

[4]Arthur, M. D. and I. F. Marshall. 1977. Vegetation survey, Bouy's Bluff, southern James Bay, summer of 1976. Ontario Ministry of Natural Resources, Moosonee District Office. 31 pp.

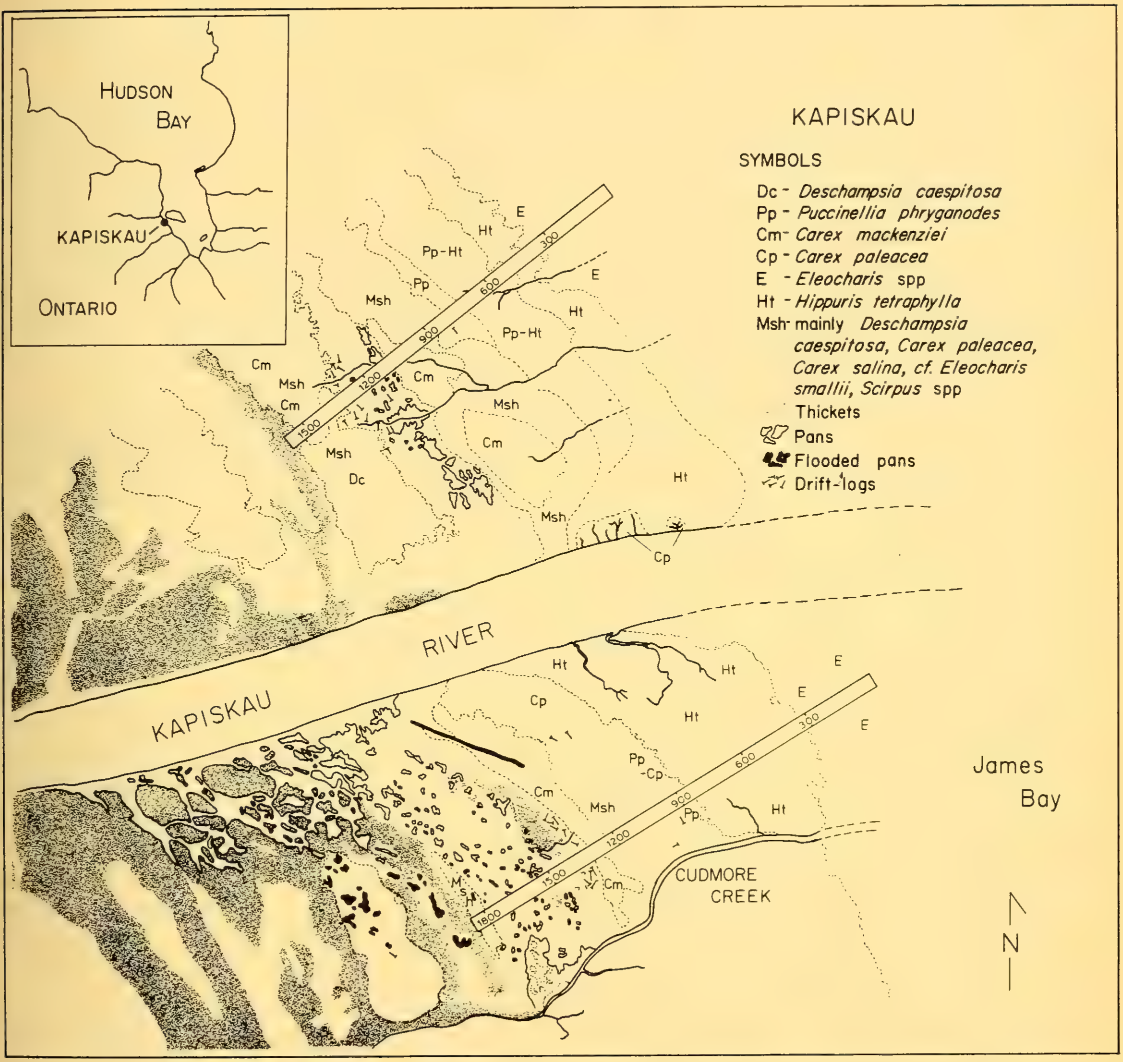

FIGURE 1. Location of study area on western James Bay (inset) and map of study area showing transects and main vegetation and surface features. The scale of the study area is shown in metres on the transects. The study area map is based on an enlargement of aerial photograph A24036-35 (Geological Survey of Canada), taken in 1975 from an altitude of ca. 8700 m asl. The information was compiled from air photo analysis including color transparencies and field notes.

1678 $m^3 \cdot s^{-1}$ and 1651 $m^3 \cdot s^{-1}$, respectively (Hutton and Black 1975).[5]

The surficial geology of the region consists of unconsolidated glacial deposits and post-glacial marine clays (Rowe 1972) overlying horizontally bedded Paleozoic limestone (Manning 1952). Since deglaciation, about 8000 yr BP (Prest 1970), the region has been emerging from under the waters of first the Tyrrell Sea and now Hudson and James bays. The leading edge of this emergence is characterized by a complex formation of low beach ridges paralleling the coastline.

Surface water salinities on James Bay are reported to range from 6‰ near the Moose River estuary to 27‰ at the mouth of James Bay (Grainger 1960) but

[5]Original flow rates were reported in terms of millions of gallons per day. The quoted rates have been rounded off to the nearest cubic metre.

large fluctuations occur owing to seasonal changes in precipitation, evaporation, freezing, ice-melt, and freshwater inflow volumes (Barber 1968). Tidal water enters James Bay in the vicinity of Cape Henrietta Maria (Godin 1972) and tidal amplitude is reported to be highest on the west coast where it is 1.8–2.4 m (Grainger 1960).

The climate is classified as modified continental because of the influence of Hudson and James bay (Chapman and Thomas 1968). At Moosonee, approximately 170 km S of Kapiskau, July temperatures average 15–16°C and daily maxima have reached as high as 32.2°C in all three summer months (Thompson 1968); however, the weather is quite variable and frost has been recorded in all months of the year. The mean annual length of the growing season is less than 140 d while at Moosonee it varies from 140–150 d (Chapman and Thomas 1968); southern Ontario has a range of 180–220 d (Brown et al. 1974).

Methods

Two transects oriented perpendicular to the coastline were established 1.0 km N and 0.8 km S of the Kapiskau River (Figure 1). They extended from the lower limit of emergent vegetation on the intertidal flat up to the first substantial thicket and were 1590 m and 1860 m long, respectively.

Elevation readings along the transects were taken at 30-m intervals over distances of 30, 60, 90, 120, and 150 m with an alidade, plane table, and stadia rod. The readings were done in sets of five from the first and subsequently every sixth datum point. Second readings were taken for each datum point subsequent to reversing the striding level in order to eliminate levelling error. Accuracy was further enhanced by the flatness of the terrain which allowed level readings to be made within each set.

Vegetation and soil were sampled at the elevation datum points. Five 10-dm^2 square quadrats were placed on lines perpendicular to the transects and spaced 15 m apart. They were labelled A, B, C, D, and E from south to north and the C quadrats were located at the elevation datum points. In each quadrat all herbaceous vascular taxa present were recorded and surface-water depth was measured. The data from the five quadrats were combined to give species frequency and mean water depth at 30-m intervals along the transects.

Soil samples to a depth of 15 cm were removed from the centers of the C quadrats and air dried. Surface water was sampled in the vicinities of the transects at intervals determined by availability. Glass jars (1 L) were filled at the sampling stations and stored in styrofoam-lined cardboard boxes. Care was taken not to agitate the water while the samples were being removed. The soil and water samples were later analyzed for water-soluble chloride ion content by using a colorimetric determination.

The vegetation and soils were sampled on 23 July–3 August and 5–12 August on the south and north transects, respectively. Water samples were collected on 4 August on the south transect and on 13–14 August on the north.

On 9 August the study area was photographed from a fixed-wing aircraft at elevations of 245 and 760 m. To facilitate locating the transects on the photographic transparencies we attached white plastic sheets to stakes at 60-m intervals along the transects. The transparencies were used to produce a map of the study area (Figure 1).

A daily record (08:00) of minimum and maximum air temperature and rainfall was kept during the study period at base camp which was situated in a small *Populus balsaminifera* (Balsam-poplar) grove about 3 km inland from the study site.

Results

Habitat

Surface elevation changes along the transects (Figure 2) outlined a series of low terraced ridges. Both transects crossed three major ridges and ended on a fourth. The north transect ridges crested at 500, 900, and 1300 m. The surface on the south transect was more irregular but ridges could be discerned at 500 m, and between 850–1250 m and 1300–1800 m. Unfortunately, the elevations of the two transects could not be coordinated and thus the elevations given in Figure 2 are independent for each transect. Overall elevation change within each transect gave slopes of 0.74 and 0.93 $m \cdot km^{-1}$ for the north and south transects, respectively, which results in a mean inland slope of 0.84 $m \cdot km^{-1}$.

High tide levels were not readily discernible on the marsh but by observing several high tides it was possible to locate the approximate positions of mean daily high tide (MDHT) on the transects (Figure 2). These positions indicate MDHT levels for the latter part of July and the first week in August. Driftlog strandlines were located on the third ridge of each transect and indicated the levels attained by the highest tides.

Much of the marsh surface was scarred with small sharp-sided depressions, low ragged scarps, and mounds of earth. These were particularly prominent near the level of the driftlog strandlines on the third ridge where many of the depressions were barren and covered by a characteristically light-colored and highly crystalline crust. Such depressions are known as salt pans (cf., Kershaw 1976; Glooschenko 1978).

Although the ridges were nearly imperceptible in the field, they were sufficient to determine surface

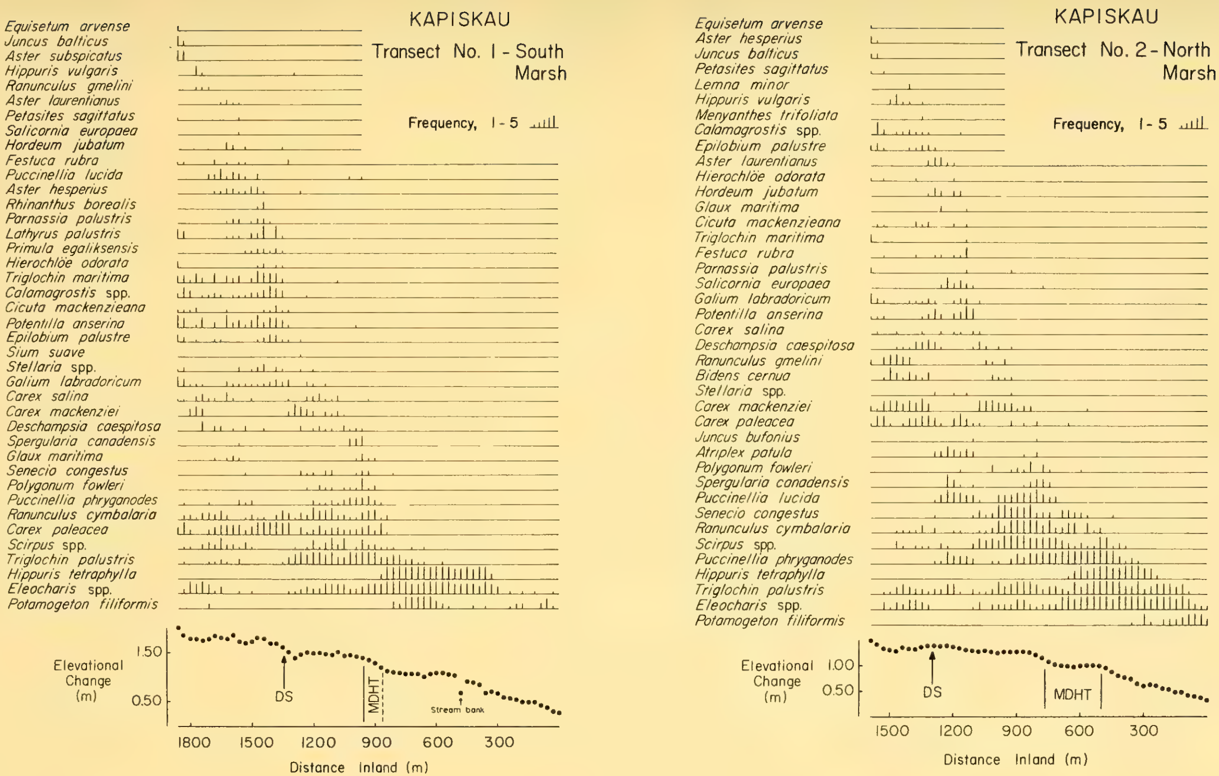

FIGURE 2. Vascular plant species frequency distributions and surface elevation changes along the north (right) and south (left) transects. Frequency was obtained by noting presence and absence for each taxon in the five quadrats located at each elevation datum point. MDHT, mean daily high tide; DS, driftlog strandline. Undetermined taxa include at least the following: *Calamagrostis*—*C. inexpansa, C. neglecta; Eleocharis*—*E. palustris, E. smallii, E. uniglumis; Scirpus*—*S. lacustris, S. maritimus* var. *paludosus; Stellaria*—*S. crassifolia, S. humifusa.*

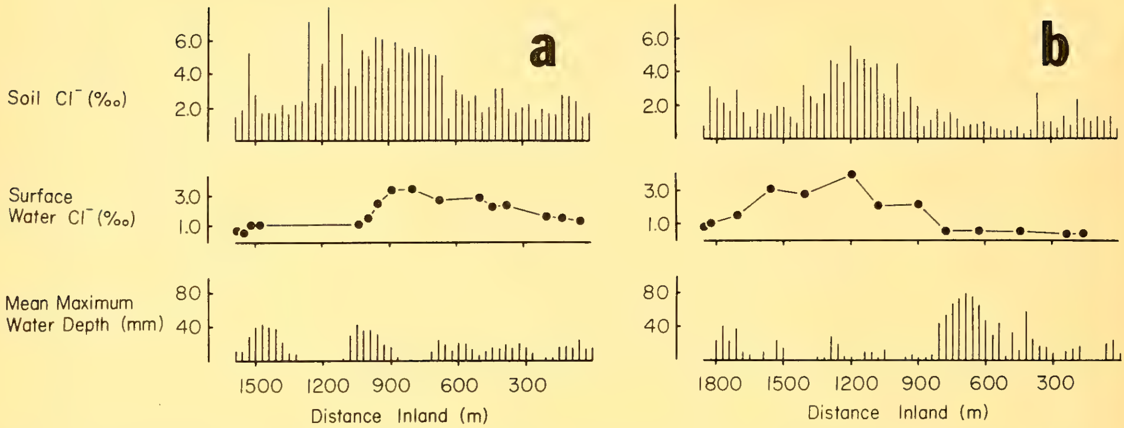

FIGURE 3. Mean maximum water depth and soil chloride ion levels along the (*a*) north and (*b*) south transects, and surface-water chloride ion levels across the marsh in the vicinities of the respective transects.

water patterns on the marsh above MDHT (Figure 3). The ridges were well drained and exposed except for local wet depressions whereas the interridges were generally covered with pools of stagnant water. The pools were shallow, rarely exceeding 10 cm in depth except in the uppermost interridges where they occasionally reached 25–30 cm. An extensive pool covered the interridge subjacent to MDHT on the south transect. This area remained completely submerged during low tide in spite of active drainage by several small streams.

Surface-water chloride ion levels on the marsh did not exceed 3.8‰. Maximum levels occurred in the area between MDHT and the salt pans on the third ridge (Figure 3). Although several factors influencing surface-water salinity such as rainfall, cloud cover, and tidal history will undoubtedly vary greatly during summer, the similarities in the chloride ion curves and levels between the two transects, even though a period of about 10 d elapsed between sampling times, suggest the results are representative of surface-water salinity conditions during late July and early August, the period of peak vegetative growth on these marshes (Glooschenko 1978).

Soil chloride ion levels paralleled surface-water chloride ion levels but were slightly higher throughout and reached a maximum of 7‰ in the salt pan area (Figure 3). None of the pans occurred in the transect series, however, so an additional sample was taken from the center of a pan located near the south transect. Prior to analysis this sample was divided into three layers on the basis of color; the very thin light-colored surface layer measured 77‰, a middle black layer, about 2 cm thick, 44‰, and a lower gray peaty layer, 26‰. It is evident that considerable salt can accumulate on these marshes under suitable conditions even though the tidal water contains very little salt.

Vegetation

Emergent phanerogamic vegetation began approximately 700–1000 m out from MDHT with small scattered colonies of *Eleocharis*[6] (*E. palustris, E. smallii, E. uniglumis*) (Spike-rush) (Figure 2). *Eleocharis* formed the initial visible zone of vegetation on the marsh but was quickly superseded by *Hippuris tetraphylla* (Mare's-tail) a much more prominent taxon which completely dominated the marsh subjacent to MDHT. The upper limit of this taxon appeared to coincide with the level of MDHT. *Potamogeton filiformis* (Pondweed), a submergent, occurred in many of the intertidal pools and extended well beyond the lower limits of the transects. *Triglochin palustris* (Arrow-grass) was also frequent in the intertidal area at least on the north transect but was scattered and patchy and was not an important element in the vegetation.

The vicinity of MDHT was dominated by *Puccinellia phryganodes* (Goose-grass) which carpeted the ground with its characteristic turf-like mats (Figure 4). This area of the marsh was mostly barren of vegetation in early July but by mid-August very little open soil remained. Considerable horizontal overlap between this taxon and *Hippuris tetraphylla* occurred on the north transect. The former, however, was restricted to firm soils which were exposed during low tide and the latter to tidal pools and wet hollows with

[6]Nomenclature follows Scoggan (1978–79).

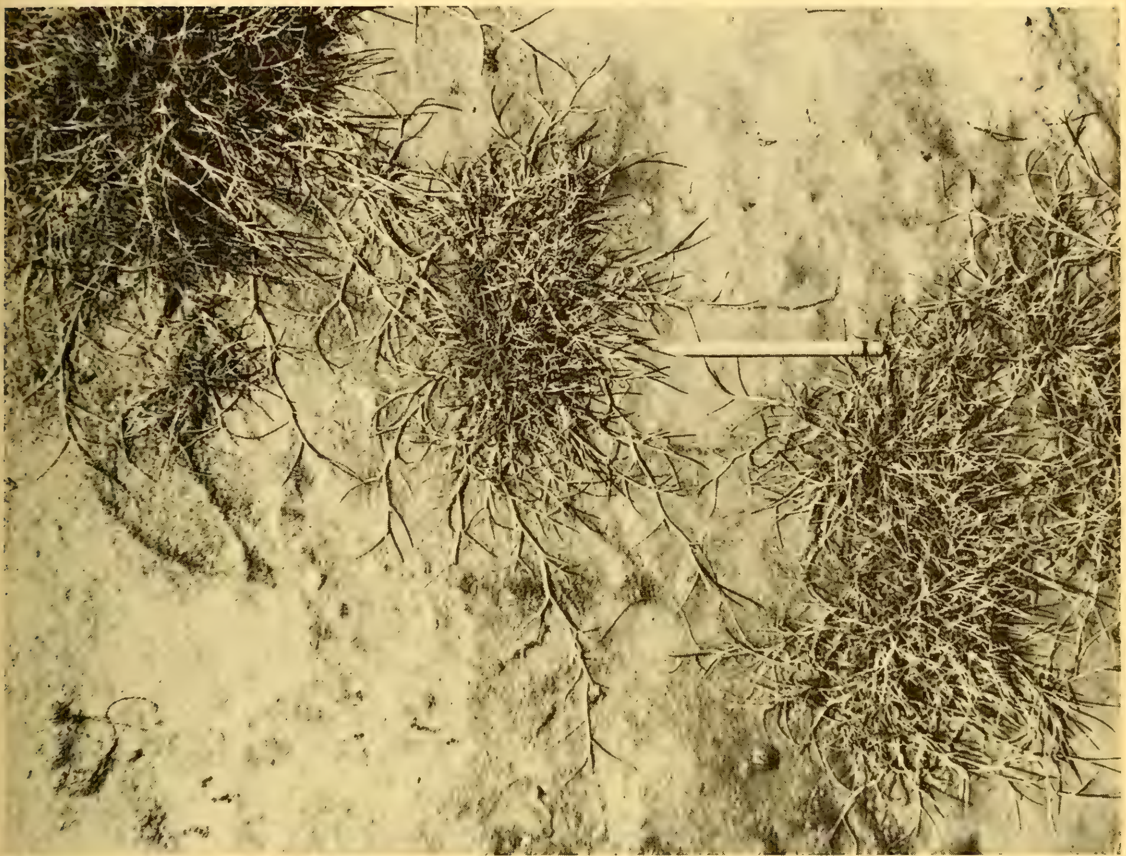

FIGURE 4. *Puccinellia phryganodes* in the vicinity of mean daily high tide, showing turf-like habit and invasion of bare ground by production of stolons.

soft soils. As a result the contact between them interdigitated over several hundred metres. In contrast very little overlap occurred on the south transect because of the large "permanent" pool of water below MDHT which excluded *Puccinellia phryganodes*. Several other taxa were also less frequent below MDHT for this reason (Figure 2). Wet hollows in the vicinity of MDHT supported mixed populations of *Scirpus* (*S. lacustris, S. maritimus* var. *paludosus*) (Bulrush), *Eleocharis, Senecio congestus* (Marshfleabane), *Ranunculus cymbalaria* (Seaside Crowfoot), and *Triglochin palustris*. *Puccinellia lucida* (Goose-grass) was frequent in dry areas on the crest of the second ridge on the north transect. *Salicornia europaea* (Glasswort) and *Atriplex patula* (Spearscale) were also present but rare. *Carex paleacea* (Sedge) occurred down to the level of MDHT on the south transect. It was expanding rapidly in this area and appeared to be superseding *Puccinellia phryganodes*. On the north transect *Carex paleacea* was rare below the level of the third ridge.

The interridge vegetation between the second and third ridges was dominated by *Carex mackenziei* (Sedge). This taxon formed extensive monospecific swards in 3–8 cm of water but in shallower water it was usually overgrown by taller taxa such as *Deschampsia caespitosa* (Tufted Hairgrass), *Carex salina* (Sedge), and *Carex paleacea*. Deeper-water habitats supported dense stands of either *Eleocharis* or *Scirpus* with the latter tolerating somewhat deeper water conditions.

The third-ridge salt pans and associated vegetation were better developed on the north transect. The pans were either barren or sprinkled with sparse to dense populations of *Salicornia europaea* and were typically bordered by *Puccinellia lucida* (Figure 5). A few metres away from the pan edge *Puccinellia phryganodes* formed dense mats. Interpan areas were vege-

FIGURE 5. Typical salt pan on the third ridge near the south transect with a sprinkling of *Salicornia europaea* and bordered by a band of *Puccinellia lucida.* A meadow of *Hordeum jubatum* occupies the foreground and the thicket on the fourth ridge can be seen on the horizon.

tated with extensive meadows of *Hordeum jubatum* (Squirrel-tail Grass). A number of prominent mounds in the pan area supported a distinct assemblage of taxa (Figure 6) which included *Carex paleacea, Potentilla anserina*[7] (Silverweed), *Triglochin maritima* (Arrow-grass), *Galium labradoricum* (Bedstraw), and *Festuca rubra* (Red Fescue).

Third-ridge vegetation on the south transect was more diversified. Scattered shrubs (*Salix*) were present and the associated herbaceous vegetation consisted primarily of *Carex paleacea, Triglochin maritima, Potentilla anserina,* and *Calamagrostis* (*C. inexpansa, C. neglecta*) (Reed-bentgrass). The salt pans were located about 200 m inland from the driftlog strandline and were part of a series of pans extending along the interridge from the Kapiskau River and Cudmore Creek (Figure 1). Evidently tidal water reaches this part of the marsh by flowing through the interridge from the river and creek, possibly during the spring freshet. Many of the pans, particularly those towards the base of the third ridge, were associated with marginal pools or were flooded entirely. As a result, the vegetation associated with the salt pans was less developed compared to the north transect. Expectedly, *Salicornia europaea* was rare and *Atriplex patula* absent on the south transect. The interridge was relatively dry and surface water was for the most part confined to localized pools. The vegetation consisted mainly of meadows of *Calamagrostis, Carex paleacea,* and *Deschampsia caespitosa* with localized stands of *Eleocharis* and *Scirpus* scattered throughout. In comparison the uppermost interridge

[7]Includes *Potentilla egedii.* These two entities could not be consistently separated in the field.

FIGURE 6. Earth mound associated with old driftlog and vegetated with *Triglochin maritima, Potentilla anserina, Aster,* and *Carex paleacea. Puccinellia phryganodes* and *Puccinellia lucida* are in foreground, and *Hordeum jubatum* is to the left and right of mound.

on the north transect was completely submerged. *Carex mackenziei* was most prominent but open water pools were numerous and often bordered with stands of *Eleocharis, Scirpus,* and *Hippuris vulgaris* (Mare's-tail).

Thickets were well developed on the fourth ridge of each transect. Common shrubs included various willows (*Salix laurentiana, S. candida, S. phylicifolia* var. *planifolia,* and *S. bebbiana*). Much rarer were *Alnus rugosa* (Speckled Alder), *Betula pumila* (Swamp-Birch), and *Myrica gale* (Sweet Gale). Dense swards of *Juncus balticus* (Rush) dominated the thicket understory while open areas supported meadows of *Calamagrostis.*

Discussion

Habitat

The main underlying factors affecting the James Bay coastal marshes are low surface slope and post-glacial land emergence which characterize the entire western James Bay–Hudson Bay coastline. The mean slope of 0.84 $m \cdot km^{-1}$ at Kapiskau compares with 0.75 $m \cdot km^{-1}$ reported at Fort Albany 60 km S of Kapiskau (Hunter 1970). Hunter also established the rate of land emergence to lie within the range of 0.9–1.2 m per century in support of a previous estimate of 1.2 m per century by Webber et al. (1970) at Cape Henrietta Maria. Using these values, the time required at Kapiskau for the vegetation to pass from the emergent stage on the intertidal flats to the thicket stage, a distance of about 1.5 km, ranges from 106 to 142 yr. This is much lower than 300 yr reported by Kershaw (1976) for the East Pen Island marsh. In arriving at his figure which is also based on Webber's estimate, however, Kershaw considered the top of the mainland ridge to be the top of the marsh but this, he pointed out, was approximately 2 m above the marsh surface. If one uses his reported slope of 1.0 $m \cdot km^{-1}$

and measures the distance between the lower limit of the first emergent and the first shrub occurrence on his generalized transect (Figure 7 in Kershaw 1976), a range of 91–122 yr is obtained, which compares favorably with the present estimate. The time required for European coastal marshes to reach the *Juncetum gerardi*, which is comparable to the thicket stage at Kapiskau, ranges from 70 yr for closed marshes to 300 yr for open marshes, assuming a stable coastline (Chapman 1974). Because the Hudson and James bay coastlines are rapidly emerging the range of 91–142 yr for the age of these marshes is likely closer to the mark than 300 yr.

The low slope and rapid rate of emergence combine to produce a situation where new land surface is being exposed at a mean annual rate of 10–15 m and hence marsh vegetation is moving seaward at the same and perhaps unprecedented rate along several hundred kilometres of coastline.

Chloride ion curves on the marsh are related to the frequency, duration, and inland extent of previous tidal inundations as well as to surface slope and insolation levels. Low surface slope accentuates small vertical variations in tidal amplitude and translates them into large horizontal variations in tidal inundation. Between MDHT and the driftlog strandlines, a distance of about 500–700 m, inundation frequency and duration decrease inland while exposure to air and subsequent evaporation increase resulting in a zone of salt enrichment. Culmination of this process occurs in the salt pan area where surface-soil chloride ion levels are several times greater than levels in the intertidal soils. In general, chloride ion levels were much lower than in normal sea-water and thus salinity conditions on these marshes indicate a brackish regime rather than a true salt marsh regime (cf., Pielou and Routledge 1976; Glooschenko 1978).

In addition to flooding the coastal marshes with brackish water, the tides, when concerted with James Bay ice, cause widespread scarring of the marsh surface. Pronounced scarring in the salt pan area, situated near the level of the driftlog strandlines, suggests the pans are formed, at least physically, by unusually high ice-bearing tides of spring. Annual tidal phenomena and salinity structures in James Bay, however, are insufficiently understood at present and further elaboration of their influence on the coastal marshes is not warranted.

Vegetation

The phanerogamic intertidal colonizers reflect the brackish condition of the James Bay tidal water. *Potamogeton filiformis*, a freshwater taxon noted for its tolerance of brackish water (Sculthorpe 1967), is a colonizer in brackish coastal marshes in Iceland (Steindorsson 1954) and on the Baltic Sea (Tyler 1969). *Eleocharis* is a typical pioneer of brackish marshes in Norway, Sweden, and Denmark (Chapman 1974) and *Hippuris tetraphylla* is the characteristic pioneer in brackish conditions in Iceland (Steindorsson 1954) and Norway (Nordhagen 1954). Jefferies (1977) has also reported *Hippuris tetraphylla* in brackish water at Tuktoyaktuk in the western Canadian Arctic. But conditions for the successful establishment of this taxon do not appear to be widespread on James Bay because at least two large estuaries, the Attawaspiskat and the Moose, apparently lack any significant populations (Pielou and Routledge 1976).

The vicinity of MDHT was dominated by *Puccinellia phryganodes*. This taxon is reported to be a sterile triploid hybrid (Dore and McNeill, *in press*) capable of reproduction only through vegetative means. Its propensity for vegetative reproduction was evident at Kapiskau by the rapidity with which it spread over the denuded area of MDHT during July and August. *Puccinellia phryganodes* is the characteristic pioneer throughout arctic and subarctic salt marshes (Polunin 1948; Chapman 1974, 1976; Jefferies 1977) and is typically found in the area of high tide (Polunin 1948).

Carex paleacea was widespread on the marsh above MDHT. Habitat variation shown by this taxon ranged from dry earth mounds in the salt pan area to shallow pools in the interridges. It was absent only in the deeper pools of the interridges and on the salt pans. In drier habitats the colonies were diffuse and mixed with other taxa, forming extensive species-rich meadows. The interridge populations, in contrast, consisted of dense nearly monospecific swards which formed mosaic patterns with other taxa rather than mixed stands. The mosaics were characteristic of the transition from well drained ridge to flooded interridge and consisted mainly of *Carex paleacea, C. salina, Deschampsia caespitosa, Eleocharis,* and *Scirpus* *Carex paleacea* is important in the James Bay coastal marshes (Ontario Ministry of Natural Resources, unpublished data; Glooschenko 1978). In North America it is found in coastal marshes as far south as the St. Lawrence River (Gauthier 1972) but was absent from the East Pen Island marshes (Kershaw 1976) on Hudson Bay indicating a temperate-zone distribution. In Europe Chapman (1974) lists *Carex paleacea* as a major sere of brackish marshes in temperate Fennoscandia.

The dominant taxon in the interridges above MDHT was *Carex mackenziei*. These areas are infrequently inundated; during this study the lower of the two interridge levels was inundated only once. A parallel situation exists in coastal marshes in Iceland and Norway where *Carex mackenziei* is typically found in wet habitats just out of reach of normal tides

(Nordhagen 1954; Steindorsson 1954). *Carex mackenziei* is widespread on the western James Bay coast (Ontario Ministry of Natural Resources, unpublished data) but was absent further north at East Pen Island (Kershaw 1976). A closely related taxon *Carex glareosa* was, however, abundant at the latter site and both were reported from the Churchill salt marshes (Schofield 1959). According to Chapman (1974) *Carex mackenziei* is widely distributed in subarctic regions of Canada and Europe.

The uppermost vegetation recorded on the Kapiskau marshes consisted of *Salix* thickets with a *Juncus balticus* understorey and open-area meadows of *Calamagrostis*. *Juncus balticus* formed the uppermost marsh vegetation zone at North Point where it had the highest biomass values for the coastal marsh (Glooschenko 1978). In western Alaska the *Salix–Juncus balticus* association was considered to be the penultimate climax vegetation (Hanson 1951). *Calamagrostis* was abundant in open habitats and common down to the level of the driftlog strandline. Below this it was represented only by occasional outliers. A similar situation was reported at East Pen Island where the lower limit of *Calamagrostis neglecta* coincided with old strandlines (Kershaw 1976).

The lower limit of substantial shrub growth was arbitrarily chosen as the upper limit of the coastal marsh vegetation. It is likely though that saltwater influence extends further inland. Chloride ion levels on the fourth ridge were still about 1‰. The presence of *Salix* on the third ridge of the south transect where soil chloride ion levels were high suggests that the thickets do not in fact mark the upper limit of saltwater influence. The transition from brackish to freshwater conditions (less than 0.5‰ all salts) may be prolonged by an apparent lag in soil salt removal because of rapid land emergence. This would result in residual saline conditions well above current extreme high-tide levels.

Frequency distributions of several taxa above the intertidal area were clearly correlated with the beach ridge topography probably through topographically controlled soil water conditions. Three patterns suggestive of a ridge-by-ridge or interridge-by-interridge movement of individual taxa in the direction of the rapidly emerging coastline were evident: outlying populations preceding (i.e., lower than) the main population, e.g., *Carex mackenziei* on the north transect; comparable populations at two or more levels, e.g., *Glaux maritima* (Sea-milkwort), on the south transect; and relict populations preceded by (i.e., at a higher level than) the main population, e.g., *Carex mackenziei* on the south transect. Complete elucidation of the vegetation dynamics on the western James Bay coastal marshes must, however, await an appropriate time-oriented investigation. Clearly a comprehensive study of these interesting and extensive ecosystems is long overdue.

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Distribution and Breeding Biology of Raptors in the Thelon River Area, Northwest Territories, 1957–1969

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Kuyt, E. 1980. Distribution and breeding biology of raptors in the Thelon River area, Northwest Territories, 1957–1969. Canadian Field-Naturalist 94(2): 121–130.

From 1957 to 1969 concentrations of nesting raptors were found along the Thelon River system, Northwest Territories. Peregrine Falcons (*Falco peregrinus*) and Gyrfalcons (*Falco rusticolus*) usually nested on south- or west-facing cliffs whereas Rough-legged Hawk (*Buteo lagopus*) nests were mostly on north- or east-facing cliffs and hillsides. Of the Gyrfalcon nests in tree-line habitat, about equal numbers were found in trees and on cliffs. Gyrfalcons appeared to prefer stick nests over scrapes. Dates of egg-laying were estimated to be 30 May – 25 June for the Peregrine Falcon, 20 April – 2 June for the Gyrfalcon, and 28 May – 20 June for the Rough-legged Hawk. Clutches of peregrine eggs averaged 3.3 and appeared to decrease in size from 1962 to 1969. Gyrfalcons fledged an average of 2.5 young per brood. Percent occupancy of Peregrine Falcon nest sites appeared unchanged until 1963 but from 1964 until 1969 declined. The decline, highly unlikely a result of human disturbance at nest sites, has continued to the present time.

Key Words: Northwest Territories, Thelon Game Sanctuary, raptors, ecology, nest sites, *Falco peregrinus, Falco rusticolus, Buteo lagopus.*

During spring and summer from 1960 to 1965, I studied Gray Wolves (*Canis lupus*) in the Thelon Game Sanctuary and in the adjoining region south to the tree line (Kuyt 1970). I also worked in the area during Caribou (*Rangifer tarandus*) studies in 1957 and 1958. In 1966, 1967, and 1968 I spent the second or third week in July on aerial surveys along the Thelon River from the junction of the Thelon and Hanbury rivers to Baker Lake. During these studies, I made detailed field notes on the occurrence and distribution of birds in the Thelon River area.

In 1965 I noticed that several Peregrine Falcon (*Falco peregrinus*) nest sites on the Thelon River, which I had observed in preceding years, were unproductive although they were attended by adult birds. The catastrophic decline of peregrines in Britain was preceded by the same phenomenon (Ratcliffe 1963). This decline has since been attributed to organochlorine pesticide contamination (Ratcliffe 1967). Declines in Peregrine Falcon populations reported in many parts of North America have been linked with high residue levels of chlorinated hydrocarbons in tissues and eggs (Hickey 1969; Peakall 1976). In some cases, human disturbance may have contributed to local declines of peregrine populations (Dekker 1967).

This paper summarizes information compiled from 1957 to 1969 on the occurrence, distribution, and breeding of raptorial birds in the Thelon River area. It is also intended as background information for current studies of pesticide residue in populations of raptors from the Thelon River area.

Although I refer to maps that show the locations of nests, these detailed maps do not accompany the paper; however, copies have been deposited in Canadian Wildlife Service files and are available to those engaged in research on raptors.

Study Area

The Thelon River system lies in the Mackenzie and Keewatin districts of the Northwest Territories (Figure 1). Clarke (1940) described the physical geography of the Thelon Game Sanctuary, and Bird (1967) and Kuyt (1970) provided additional information. Because many of the nest sites are located along the Thelon River system, the river and raptor nesting habitat will be described in detail.

Above its junction with the Hanbury River, the last few kilometres of the Thelon River are shallow with a number of rapids. The banks of the river and islands in that area are composed of steep, crumbling sandstone cliffs with numerous ledges and small caves. Between the last falls below Dickson Canyon and its confluence with the Thelon River, the Hanbury flows through a narrow trough with gently sloping banks. A few isolated rock ledges and steep banks near Tyrrell's "Hawkrook" (Tyrrell 1902), constitute potential nest sites or roosting areas for raptors.

From its junction with the Hanbury River to Hornby Point, the Thelon River flows through a predominantly sandy area; its banks are low and offer few nest sites for raptors. From Hornby Point, the area is heavily wooded for about 20 km downstream and the river banks slope gently for 40 km. In this section, there are only two cliffs of crumbly sandstone and a dirt bank where Peregrine Falcons are known to have nested.

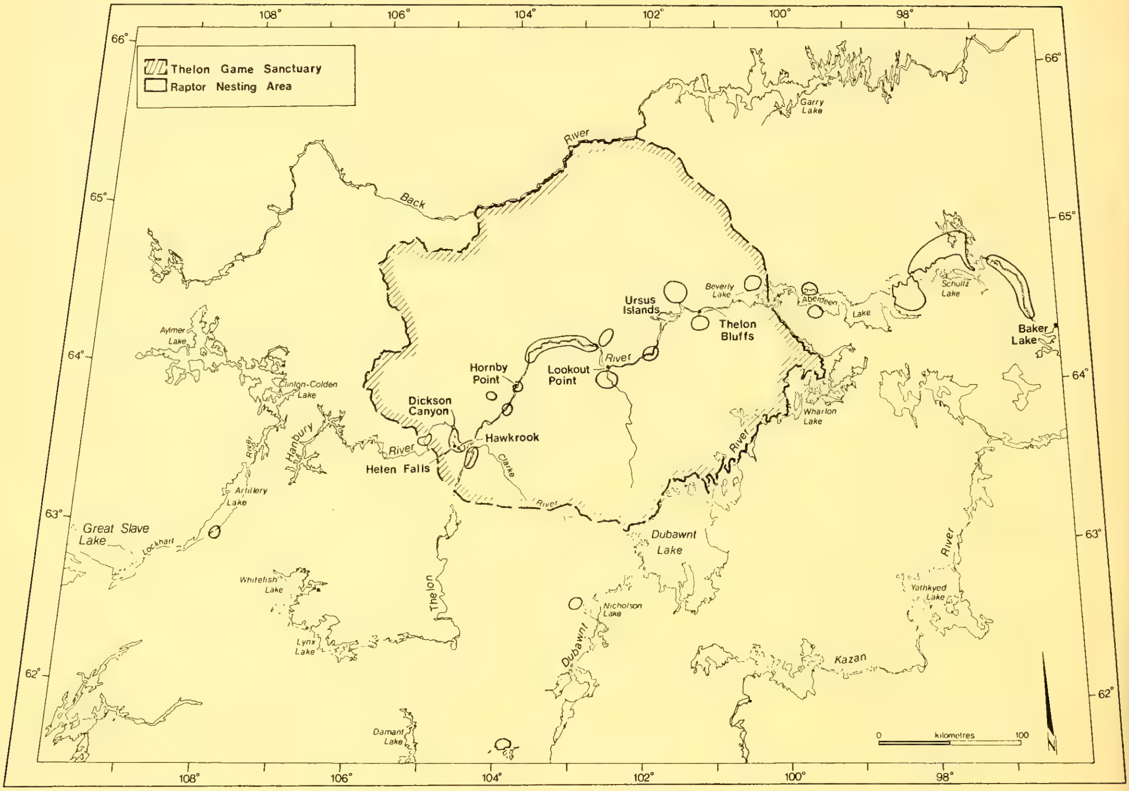

FIGURE 1. Distribution of raptor nesting areas, Thelon River area, Northwest Territories.

After turning eastward at approximately 103°40′W, the Thelon River runs swiftly through a series of sharp bends. Here it has cut a deep channel in the sandstone and almost every bend is marked by a steep cliff rising to about 15 m above the water. Rough-legged Hawks (*Buteo lagopus*) and Peregrine Falcons are regularly seen, and many nest sites have been found.

After completing its tortuous route through this sandstone formation, the Thelon River flows more slowly around three groups of islands before reaching Lookout Point. Peregrine Falcons and Rough-legged Hawks have not been known to nest along this section of the river, although single birds are occasionally seen. Trees here are occasionally used as nesting sites by Gyrfalcons (*Falco rusticolus*).

From Lookout Point to Ursus Islands, a distance of 55 km, much of the Thelon River area is wooded, particularly the left bank. Peregrine Falcons and Rough-legged Hawks are rarely seen and are not known to nest here, although several Gyrfalcons have been observed in tree nests in this area.

At Ursus Islands the Thelon turns sharply eastwards and flows into Beverly Lake. The banks of the river are high but not precipitous, with few possible nest sites for falcons or for Rough-legged Hawks. Tree growth practically ceases at Thelon Bluffs, which are located about 25 km upstream from Beverly Lake.

The rugged terrain 15 to 25 km NW of Ursus Islands and 25 km NW of Beverly Lake provides suitable habitat for raptors. Even though Beverly and Aberdeen lakes are large tundra lakes with few hills near their shores, Rough-legged Hawks are more abundant here than along the previous section of the Thelon River. The nests are built on the banks or sides of gullies and are easily accessible. A few peregrines are also found here, and one unusual peregrine nest site at the northwest corner of Aberdeen Lake is as readily accessible as the rough-leg nests in the area (Kuyt 1966).

The final section of the Thelon River area from the east end of Aberdeen Lake through Schultz Lake and the lower Thelon River contains numerous escarpments and an abundance of existing and possible nest sites for raptors.

Methods

The locations of nest sites, nesting birds, and of apparently non-nesting raptors, were plotted on topographical maps (scale 1:2500000, 1:1000000, and 1:506880, Department of Energy, Mines and Resources). Three detailed maps showing the distribution of raptors and raptor nest sites (1) from 1957 to 1969 along the Thelon River; (2) from 1951 to 1969 along the middle and lower Thelon River; and (3) during the summers of 1963, 1965, and 1966 along the Thelon River (data of J. A. Donaldson), have been deposited in Canadian Wildlife Service files. Donaldson apparently did not distinguish between Peregrine Falcons and Gyrfalcons but stated that most of the falcons he saw were peregrines.

In most cases, nests were visited once each year with as little time as possible spent at active nests to avoid undue disturbance. Measurements of eggs were taken when possible, and 26 Peregrine Falcons, 15 Gyrfalcons, and 13 Rough-legged Hawks were banded as nestlings during the study. The age of chicks found in nests was estimated from criteria described by Bent (1938), Cade (1960), Fox (1964), and Dement'ev et al. (1966), and from my observations of the development of one Peregrine Falcon and four Gyrfalcon chicks in captivity. The approximate dates of egg-laying by the three species of falcon and by Rough-legged Hawks were then calculated from these criteria and from the periods of incubation described by Cade (1960), Fox (1964), Burns (*in* Sealy 1966), and Witherby (*in* Godfrey 1966).

"Nest site" is the term used to describe an area where active nests, abandoned nests, or, in two cases, recently fledged young raptors were observed. Ratcliffe (1963) used the term "territory" to define the hypothetical area containing all the nesting places of a breeding pair. Nest sites frequently contained more than one nest, but only one was used each year except at three nest sites where two nests, not in view of each other, were occupied simultaneously. Nest sites were called "occupied" when adults and eggs or young were present or when a clutch was known to have been deserted.

Results

Along the Thelon River, Peregrine Falcons, Gyrfalcons, and Rough-legged Hawks were concentrated in the vicinity of the Hanbury-Thelon-Clarke river junction, along the middle Thelon River, northwest of Beverly Lake and in the area of the lower Thelon River, including the rugged portions of the north shore of Schultz Lake (Figure 1).

I located 13 peregrine nest sites, nine Gyrfalcon nest sites, one Merlin (*Falco columbarius*) nest site, and 18 Rough-legged Hawk nest sites within the Thelon River area. All peregrine nest sites checked were occupied until 1963 but occupancy dropped to 27% in 1969 (Table 1). Gyrfalcon nest occupancy varied

TABLE 1—History of occupancy of peregrine nest sites along the Thelon River. N = Newly discovered nest site; N_b = female and clutch of four eggs collected; V = vacant nest site; V_c = male only at nest site; O = occupied nest site; — =No information

Nest site number	1951	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
7						N	O	V	O	V	V	V
8	N	—	—	—	—	O	O	V	O	V	V	V
9						N	V	V	V	V	V	—
10							N	V	—	O	O	O
15					N	O	O	O	O	V	V	V
16								N	V	O	O	V
19					N	O	V	V	V	V	V	V
26	N	—	O	O	O	O	O	O	O	O	V	V
30												N
32									N	O	V	V
33									N_b	V_c	O	O
34		N	O	—	O	—	—	—	—	—	—	—
35										N	O	V
Occupied	2	1	2	1	4	6	5	3	6	5	4	3
Vacant							2	5	3	6	7	8
Percent occupied			16/16 = 100%				71	38	67	45	36	27

TABLE 2—History of occupancy of Gyrfalcon nest sites along the Thelon River. N = Newly discovered nest site; N_b = abandoned clutch; V = vacant nest site; O = occupied nest site; — = No information

Nest site number	1961	1962	1963	1964	1965	1966	1967	1968	1969
1							N	—	—
2							N	—	—
7							N_b	V	V
15							N	O	O
17	N	O	O	V	O	V	V	V	—
19						N	O	V	V
20				N	O	V	V	V	—
29							N	—	—
31								N	O
Occupied	1	1	1	1	2	1	6	2	2
Vacant				1		2	2	4	2
Percent occupied		100		50	100	33	75	33	50

between 100 and 33% from 1961 to 1969 (Table 2). Nest sites of Rough-legged Hawks were rarely found occupied more than 2 yr in succession (Table 3). In several instances, all three species used the same nest in different years.

Peregrine Falcons and Gyrfalcons selected nest sites with a southern or western exposure while Rough-legged Hawk nest sites faced predominantly north or east (Table 4). Gyrfalcons in the Thelon River area nest on ledges of cliffs or in trees (Kuyt 1962). Of 21 nests examined, four were scrapes located on ledges and 17 were stick nests. In treeless areas three Gyrfalcon nests were found on cliffs, while in forested areas, seven of 18 nests were in White Spruce (*Picea glauca*) trees and 11 were on cliffs.

Raptors were first seen in spring at Lookout Point (Figure 1) as follows: Rough-legged Hawk on 28 May, Gyrfalcon on 29 May, and Peregrine Falcon and Mer-

TABLE 3—History of occupancy of Rough-legged Hawk nest sites along the Thelon River. N = Newly discovered nest site; N_b = abandoned clutch; N,N_b = one nest with four young, other nest and three eggs abandoned; N_t = two nests; V = vacant nest site; O = occupied nest site; — = No information

Nest site number	1957	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
2					N_b	—	—	—	—	—	—
5									N_b	—	—
9									N	—	—
11						N	V	V	V	V	V
12						N	V	V	V	O	V
14						N	O	V	O	V	O
15						N	V	V	V	V	V
16									N	V	V
18									N,N_b	V	V
19									N	V	V
21										N	—
22										N	—
23			N	—	—	—	—	—	—	V	—
24										N	—
25			N	O	O	O	—	—	—	—	O
27				N	V	V	—	—	—	—	—
28	N	—	—	—	—	—	—	—	—	—	—
30		N_t	—	O	—	—	—	—	—	—	N_b
Occupied	1	1	2	3	2	5	1	Nil	6	4	3
Vacant					1	1	3	4	3	7	6
Percent occupied	100	100	100	100	67	83	25	Nil	67	36	33

lin on 6 June. The first observation of a Golden Eagle (*Aquila chrysaetos*) was not made until 27 June, while the Bald Eagle (*Haliaeetus leucocephalus*), observed on only two occasions, was first seen on 30 June.

Four recently fledged gray Gyrfalcons were observed in 1965 in a nest in a White Spruce, beside an unnamed lake at 61°45′N, 104°W. This observation would appear to be the southernmost breeding record for Mackenzie District.

Merlin nests were found only in wooded terrain in the study area. Merlins seen during late August on the shore of Artillery Lake were probably post-nesting strays.

Only one pair of Golden Eagles was seen during the study but no search was made for a nest site. Golden Eagles are more common along the Thelon River from Lookout Point to Thelon Bluffs than anywhere else in the study area. J. P. Kelsall (personal communication) saw single birds near the Thelon-Hanbury junction and 30 km downstream from Lookout Point, but Clarke (1940) did not see any Golden Eagles along the Thelon River.

A pair of Bald Eagles was seen in a thinly forested area west of Nicholson Lake in July 1965, and in the same year a single bird was observed at 64°13′N, 101°05′W feeding on a dead Caribou calf. Tourists observed a pair of Bald Eagles in 1968 near Hornby Point. Neither Hornby (1934) nor Clarke (1940) saw these eagles along the Thelon River.

Measurements of eggs of Peregrine Falcons, Gyrfalcons, and Rough-legged Hawks are presented in Table 5. The mean weights of eggs are listed, even though it is known that egg weights decrease as incubation progresses (Pettingill 1939) and the stage of incubation was not reported in all cases.

The mean sizes of Peregrine Falcon clutches and broods were 3.3 and 2.9 respectively (Table 6); mean

TABLE 4—Nest orientation of raptors in the Thelon River area

Orientation	Peregrine Falcon	Gyrfalcon[a]	Rough-legged Hawk
	Total nests (%)	Total nests (%)	Total nests (%)
Facing north	3 (9)	1 (10)	11 (42)
Facing east	1 (3)	1 (10)	9 (35)
Facing south	16 (47)	4 (40)	4 (15)
Facing west	14 (41)	4 (40)	2 (8)
Total	34 (100)	10 (100)	26 (100)

[a]Cliff nests only.

TABLE 5—Measurements of raptor eggs from nests along the Thelon River

Species	Mean measurements (n)		
	Length (mm)	Width (mm)	Weight (g)
Peregrine Falcon	52.0 (20) Range 49–55	41.2 (20) Range 39–43	41.7 (13)[a] Range 30.4–46.9
Gyrfalcon	56.0 (3) Range 55–57	45.0 (3) Range 45	57.2 (3)[b] Range 54.6–59.7
Rough-legged Hawk	54.7 (7) Range 52–58	43.7 (7) Range 42–46	52.6 (7)[c] Range 47.9–57.1

[a]Ten eggs contained large embryos, one embryo was partially developed, two eggs were addled.
[b]Eggs contained dead embryos.
[c]Two eggs contained dead embryos, three eggs had no embryos, contents of two eggs unknown.

TABLE 6—Average clutch or brood size of Peregrine Falcons along the Thelon River

Year	Number of nests containing						Average clutch & brood size
	2 eggs	2 young	3 eggs	3 young	4 eggs	4 young	
1951		1		1			2.5
1960					1		4.0
1961					1		4.0
1962				1	2		3.7
1963		1			1	3	3.6
1964		1		2			2.7
1965		1		1			2.5
1966	1	1	1	1	1		2.8
1967	1		3				2.8
1968			1	1			3.0
1969				1			3.0
Total		7		13		9	3.1

size of clutch and brood was 3.1 (Table 6). No data are available on brood size at fledging. Gyrfalcons are early nesters and the only set of eggs seen was an abandoned clutch of four found in 1967. Eighteen broods were found and the mean brood size was 2.9. Six fledged Gyrfalcon broods were observed and their mean brood size was 2.5. Only two Merlin nests were found: one contained four eggs and the other had four young and an addled egg. Four abandoned clutches of Rough-legged Hawks were found: two of these consisted of two eggs, and two consisted of three eggs. Two clutches of five eggs each, with parents in attendance, were also observed.

I estimated dates of egg-laying by Peregrine Falcons to be from 30 May to 25 June (Table 7), by Gyrfalcons from 20 April to 2 June (Table 8), and by Rough-legged Hawks from 28 May to 20 June (Table 9). In the two Merlin nests found, eggs appeared to have been laid about 3–5 June in one case and about 12–14 June in the other.

Cade (1960) stated that immature birds are extremely rare within the range occupied by the breeding population. I observed two peregrines on 21 July 1962 as they were flying over the Hanbury River near Helen Falls. A third was seen in 1964 at Lookout Point. Judging by their plumage I considered the three to be yearlings. An immature female Gyrfalcon was observed at close range on 29 July 1965. The bird's color and molt pattern were similar to those of a captive yearling Gyrfalcon. I saw an immature Golden Eagle on one of the Ursus Islands on 21 July 1960, and

TABLE 8—Estimated dates of egg-laying by Gyrfalcons in the Thelon River area

Site (year)	Young	Estimated age (d)	Estimated date of laying
19 (1967)	3	7	2 June
20 (1965)	3	14	10 May
19 (1966)	3	14	22 May
17 (1965)	4	14	5 May
15 (1968)	2	21	26 May
17 (1961)	3	21	30 April
17 (1962)	3	21	30 April
3A (1966)	3	21	17 May
29 (1967)	3	21	21 May
17 (1963)	4	21	30 April
20 (1964)	3	28	9 May
3A (1967)	3	40–50	3 May
31 (1968)	2	40–50	4 May
31 (1969)	2	40–50	11 May
2A (1965)	4	40–50	27 April
2 (1967)	3	40–50	20 April
3A (1969)	2	40–50	9 May
15 (1969)	2	40–50	8 May

TABLE 7—Estimated dates of egg-laying by Peregrine Falcons along the Thelon River

Site (year)	Young	Eggs	Estimated age of young (d)	Estimated date of laying
30 (1969)	1	2[a]	1 or 2	25 June
33 (1968)	2	1	1 or 2	17 June
33 (1969)	3	—	1 or 2	24 June
26 (1964)	2[b]	2	1 or 2	7 June
26 (1963)	3[b]	1	1 or 2	11 June
7 (1966)	2	—	7	30 May
8 (1966)	3	—	7	30 May
16 (1968)	3	—	7	9 June
10 (1969)	1	1[a]	14	13 June
15 (1962)	3	—	14	6 June
9 (1963)	4	—	14	8 June
7 (1963)	2	—	21	3 June
7 (1964)	2	—	21	1 June
16 (1965)	2	—	21	5 June
8 (1964)	3	—	21	30 May
15 (1964)	3	—	21	4 June
15 (1965)	3	—	21	5 June
8 (1963)	4	—	21	7 June
15 (1963)	4	—	21	8 June

[a]One egg addled.
[b]One young just hatched.

TABLE 9—Estimated dates of egg-laying by Rough-legged Hawks in the Thelon River area

Site (year)	Young	Eggs	Estimated age of young (d)	Estimated date of laying
14 (1968)	1	1	1 or 2	20 June
3A (1966)	1[b]	2	1 or 2	11 June
18 (1966)	4[b]	—	1 or 2	9 June
19 (1966)	4[b]	1	1 or 2	8 June
12 (1967)	3	—	10	3 June
21 (1967)	3	—	10	5 June
25 (1968)	3	—	10	12 June
28 (1957)	3	1[a]	10	19 June
14 (1964)	3	—	14	11 June
16 (1966)	4	—	14	28 May
11 (1963)	3	—	21	7 June
12 (1963)	3	1[a]	21	14 June
14 (1963)	4	—	21	7 June
15 (1963)	3	—	30	4 June

[a]Egg addled
[b]One young just hatched

R. W. Fyfe (personal communication) photographed one on the middle Thelon River in 1970. All immature birds seen were within the ranges of breeding adults.

A leg-banded Peregrine Falcon from the middle Thelon River was recovered 5½ mo later in Argentina (Kuyt 1967), and a second peregrine banded as a nestling on 1 August 1963 along the middle Thelon River was recovered 6 yr later in Peru. A young Gyrfalcon, banded in 1968 in the same area was recovered 2½ mo later near Mattice, Ontario.

Remains of prey observed at Peregrine Falcon nest sites included immature Gray-cheeked Thrush (*Catharus minimus*), Lapland Longspur (*Calcarius lapponicus*), and unidentified passerines and shorebirds. Remains of prey observed at Gyrfalcon nest sites included ptarmigan (*Lagopus* sp.), Short-eared Owl (*Asio flammeus*), Pintail (*Anas acuta*), Oldsquaw (*Clangula hyemalis*), unidentified ducks, Hudsonian Godwit (*Limosa haemastica*), Savannah Sparrow (*Passerculis sandwichensis*), Tree Sparrow (*Spizella arborea*), Arctic Hare (*Lepus arcticus*), Ermine (*Mustela erminea*), and Arctic Ground Squirrel (*Spermophilus parryii*). Prey items found near Rough-legged Hawk nests in the Thelon River area included remains of Northern Red-backed Voles (*Clethrionomys rutilus*), Collared Lemmings (*Dicrostonyx torquatus*), an immature Savannah Sparrow, and an Arctic Ground Squirrel.

Discussion

Distribution and Nest Sites

Distribution of nesting pairs of Peregrine Falcons appeared to be limited by availability of suitable nest sites rather than by availability of prey species. Cade (1960) stated that food is seldom an important limiting factor to populations of species of the genus *Falco*. As was found by Cade (1960) in tundra regions of Alaska, I noted that passerines and shorebirds were principal prey items of peregrines along the Thelon River and these groups of birds were abundant in my study area. It is not known, however, what factors determine the distribution of Gyrfalcon pairs in the Thelon River area, because nesting was not restricted to cliffs but also occurred in trees. In northern Yukon, Platt (1976) found that Gyrfalcon nests were concentrated in river valleys where Willow Ptarmigan (*Lagopus lagopus*) were common. The relationship of Gyrfalcon distribution to food availability and snow conditions during spring in the Thelon River area requires clarification. Distribution of Rough-legged Hawks is variable, as periodic population crashes of small mammals affect density and productivity of these raptors.

Most of the raptor observations were made at Lookout Point, even though the nearest nest was 12 km away. The length of time spent at the main camp here probably accounts for this large number of observations.

Both Peregrine Falcons and cliff-nesting Gyrfalcons used nest sites facing south or west. These sites could have been selected because of early snow melt, although other factors may have been involved. Cade (1960) considered that peregrine nests along the Yukon and Colville rivers in Alaska were oriented to afford protection from summer winds and storms. Peregrine Falcons in the Thelon area, although using

similarly oriented cliffs as Gyrfalcons, appear to be satisfied with cliffs or cutbanks much more accessible by man or other predators than those used by Gyrfalcons. Although there are exceptions to that observation, many peregrine nests could be reached by descent from above without climbing ropes. At least three nests were simply "ground-nests." Platt (1976) found that Gyrfalcons that were observed in January and February in northern Yukon used both snow-free and snow-filled nest sites prior to breeding, but sites that were at that time snow-free tended to be used more often for egg-laying in April. Gyrfalcons breed earlier than other raptors in northern areas (Tables 7, 8, 9) and may either overwinter or arrive at nesting areas several weeks prior to breeding (Platt 1976). Along the Clarke River, immediately south of the Thelon Game Sanctuary, Gyrfalcons were observed in midwinter near tree-line when several were killed by feeding on strychnine-loaded Caribou meat intended for wolves (the late Fred Riddle, personal communication). It is not known to what extent Gyrfalcons may be dependent on carrion during winter. Their choice of nest sites appears to be determined in part by lack of accumulation, or early loss of snow from sites (Cade 1960; Platt 1976), and in part by availability of food in winter or early spring (Platt 1976). Cade (1960) related selection of nest sites by Gyrfalcons in Alaska to steepness of cliffs and to shelter from overhanging ledges. Platt (1976) found that the majority of Gyrfalcon nests observed in northern Yukon were without a prominent overhang. In the Thelon River area only three of nine cliff nests had overhanging ledges. Most of the cliff nests were accessible without the use of climbing ropes, but these nests would not have been easily accessible to quadrupedal predators.

Cliff-nesting Gyrfalcons in this study appeared to favor stick nests rather than scrapes. Gyrfalcons may construct their own nests or take over the nests of other birds (Dementiew 1960; Cade 1960; Brüll 1964; Platt 1976). In some instances Common Raven (*Corvus corax*) nests appeared to have been used, but these birds are not common in the area. One tree nest along the Thelon River may have been built by Gyrfalcons; others may have been built by Gyrfalcons or by ravens, and one huge stick nest appeared to have been built by Golden Eagles. No Rough-legged Hawk nests were found in trees in the area. Most Gyrfalcon tree nests were loosely built structures which probably lasted only a single season. Seven of 18 Gyrfalcon nests in forested areas were found in trees. Cade (1960) had no records for tree-nesting Gyrfalcons in Alaska but others have reported them nesting in the circumpolar taiga of the USSR (Dement'ev et al. 1966) and Canada (MacFarlane 1891; Kuyt 1962). Siberian Gyrfalcons (*F.r. uralensis*) nest in larch (Dement'ev et al. 1966) whereas Thelon Gyrfalcons nest in White Spruce. A definite orientation to tree nests could not be assigned. Newton (1976) considered that tree-nesting by Gyrfalcons and by Peregrine Falcons was maintained by local tradition.

Peregrine Falcons and Gyrfalcons did not nest in close proximity in the study area, and competition for nest sites is therefore a possibility. White and Cade (1971) found that these two species sometimes nested on the same cliff as long as nests were out of view of one another. In the Thelon area I found several instances of Gyrfalcons or Peregrine Falcons nesting close to Rough-legged Hawks as well as the three species using the same nest in different years. The accessibility and exposure of most Rough-legged Hawk nests in the area suggest that rough-legs may be limited by interspecific competition. Even though peregrines and rough-legs may nest in the same area and young from both nests fledge successfully, the relations are not always amicable (McEwen 1957). Cade (1960) discussed this relationship in detail.

The observed decline in occupancy of peregrine nest sites from 71% in 1964 to 27% in 1969 continued to only 8% in 1975 (Cade and Fyfe 1970; Fyfe et al. 1976). This decline appears to have been part of a general decline in Peregrine Falcon populations throughout most of North America (Fyfe et al. 1976). Percent occupancy of Gyrfalcon and Rough-legged Hawk nest sites in the Thelon area was variable and no trend could be detected. Peregrine Falcons are more dependent on migratory prey species in summer than are Gyrfalcons and Rough-legged Hawks, and the southern range of peregrine migration, as indicated by recovery of two banded individuals in South America, indicates that they are subject to greater year-round exposure to DDT and other organochlorine pesticides than are Gyrfalcons and Rough-legged Hawks.

Nesting Phenology and Clutch Size

The Thelon River area was not visited until after ice breakup at the end of May, so that times of first arrival of raptors could not be determined. Nest sites could not be visited at the same time each year and the influence of environmental factors on nesting phenology among years could not therefore be determined.

Peregrine Falcons nested during June and those in the westernmost part of the area laid clutches about 2 wk earlier than those near Baker Lake. Nesting phenology therefore appeared to be closely related to spring breakup, which is earlier in the upper Thelon River than near Baker Lake. Many migratory birds that are important prey for Peregrine Falcons were observed to leave the Lookout Point area by the middle of August and peregrines are therefore under pressure to raise their young to the flying stage prior to migration of prey.

Gyrfalcons were estimated to nest about a month earlier than Peregrine Falcons, but nesting phenology of this species and of Rough-legged Hawks did not follow the same pattern of spring breakup as that of peregrines, probably because of greater dependence on non-migratory prey. Estimated dates of egg-laying were similar to those reported for Gyrfalcons by Cade (1960), but somewhat later than those reported by Platt (1976). Platt (1976) reported renesting of Gyrfalcons in northern Yukon, and the wide variation in nesting phenology of Gyrfalcons indicates that this phenomenon may also occur in the Thelon River area.

Egg-laying by Rough-legged Hawks was estimated to occur from late May until after the middle of June, and may reflect the greater dependence of this species on microtines for food and therefore on the phenology of snowmelt in the area. Rough-legged Hawk populations have been observed to fluctuate in response to fluctuations in populations of microtines (Bent 1937; Snyder 1957). Lemmings were common in the area in 1960 but populations appeared to be low in 1961 and 1962. In 1964 only one lemming was seen during 2½ mo of field study and only one rough-leg nest was occupied.

The average Peregrine Falcon combined clutch and brood size was 3.1 (range 2.5–4.0). From 54 peregrine nests in Alaska, Cade (1960) found an average clutch size of 3.0. The single nesting pair in the Thelon River area in 1975 produced a brood of three young (Fyfe et al. 1976). Declines of peregrine populations in other areas have been associated with reproductive failure (White and Cade 1971; Peakall 1976; Fyfe et al. 1976; Haugh 1976) including eggshell thinning and increased embryo and fledgling mortality. Whether this has occurred in the Thelon River area cannot be ascertained from the available data.

Bent (1938) reported that 61 Peregrine Falcon eggs in the United States National Museum averaged 52 mm by 41 mm, almost identical to the means of the 20 eggs measured in this study. The mean length and width of three Gyrfalcon eggs and seven Rough-legged Hawk eggs were similar to those recorded by Bent (1937).

Importance of Nest Sites

Observations made during the slow recovery of peregrine populations in Great Britain since 1963 have shown that pairs of Peregrine Falcons are using the same cliffs and, in some instances, the same nest sites that were used prior to the decline (Ratcliffe 1973 *cited by* Fyfe et al. 1976). Fyfe et al. (1976) concluded that cliff sites that have been used previously by peregrines should be protected regardless of their present status of occupancy, because future recovery of populations will depend on protection of such sites. Identification of nest sites in the Thelon River area indicates the relative importance of this area to Peregrine Falcons. In addition, the area contains both cliff-nesting and tree-nesting Gyrfalcons which, to date, have been reported to occur in only one other area in North America.

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Effects of Recreational Use of Shorelines on Breeding Bird Populations

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Field studies were conducted at six lakes in southern Ontario to investigate the effects on breeding bird populations of the disturbance caused by recreational use of shorelines. The degree of land development observed created extensive edge habitat but had only moderate effects on other vegetation characteristics. Although disturbed areas had significantly more birds, they tended to have lower species diversity than more natural areas. Species richness remained fairly constant in both disturbed and isolated study areas whereas species evenness was significantly lower in the former. The species composition of bird populations in study areas was also affected by disturbance. Nesting success of Common Loons (*Gavia immer*) and Eastern Kingbirds (*Tyrannus tyrannus*) was lower in disturbed areas.

Key Words: birds, recreation, land development, species diversity, nesting success, breeding, beaches, environmental effects, community composition, Ontario, Rideau Lakes.

Recent decades have seen a marked and continuous rise in outdoor recreational activity. Unfortunately, the heavy use of natural landscapes for recreation sometimes threatens the resources (e.g., lakes, forests) that people are seeking. To determine the capacity of a natural environment for recreational activity, as is necessary for adequate planning and control, a quantitative knowledge of the effects of such use on the environment and the biota is required. The objective of this study was to investigate the impact of recreational use of land and water on the breeding bird assemblages of shoreline communities. The avian component of the community was selected for analysis because it represents a portion of the biological environment which (*a*) is particularly attractive to many users of recreational areas, (*b*) is often conspicuous and thus vulnerable to human activity, and (*c*) is sensitive to the changes in vegetation structure and other habitat variables which may result from development of cottage property (MacArthur 1964; Willson 1974).

Methods

Study Areas

Shorelines of six of the Rideau Lakes in southeastern Ontario were chosen for study because of their location in a popular recreational area, with use of shorelines varying from light to heavy (Figure 1). Indian (44°35′N, 76°19′W) and Sand (44°34′N, 76°20′W) lakes are both densely surrounded by cottages, and along with Lake Opinicon (44°34′N, 76°20′W) are connected via locks as part of the Rideau Waterway. They are thus subject to heavy non-resident boat use as well as local traffic. Crow (44°32′N, 76°19′W) and Lower Rock (44°31′N, 76°19′W) lakes, on the other hand, with large portions of unused land, have only small numbers of cottages and reduced levels of boat use. Hart Lake (44°32′N, 76°20′W) is landlocked and has no access road; it is therefore without buildings and is subject only to the traffic of those boats that may be portaged. Although Lake Opinicon is part of the Rideau Waterway, it is extensive and borders large undisturbed tracts of land, in the vicinity of which boat use is limited.

Twenty-five study areas, each 400 m long and 50 m wide (2 ha) running parallel and adjacent to the lakeshore, were selected for comparative purposes. Some were located in highly disturbed areas on Sand and Indian lakes as well as on portions of Lake Opinicon, while others were on the more isolated regions of Opinicon and on Hart, Crow, and Lower Rock lakes. Each study area was given a disturbance rating based on the intensity of use in three categories: (1) density of cottages in the study area, (2) proximity of roads to the study area, and (3) boat traffic adjacent to the shoreline of the study area. Serving as one measure of the level of human activity, this last factor was investigated by assessing relative boat traffic within 25 m of the shoreline of each study area during 4 consecutive days in early July 1976. Scores were assigned for each of these use categories as shown in Table 1. The overall disturbance level of a study area was determined by summing the values in the three categories. Disturbance scores ranged from 1 to 11 with increasingly heavy use. Areas scoring 1 or 2 were considered undisturbed; those scoring $\geqslant 3$ were considered disturbed. Scoring was done prior to the analysis of impact data in order to avoid biasing the interpretation of results.

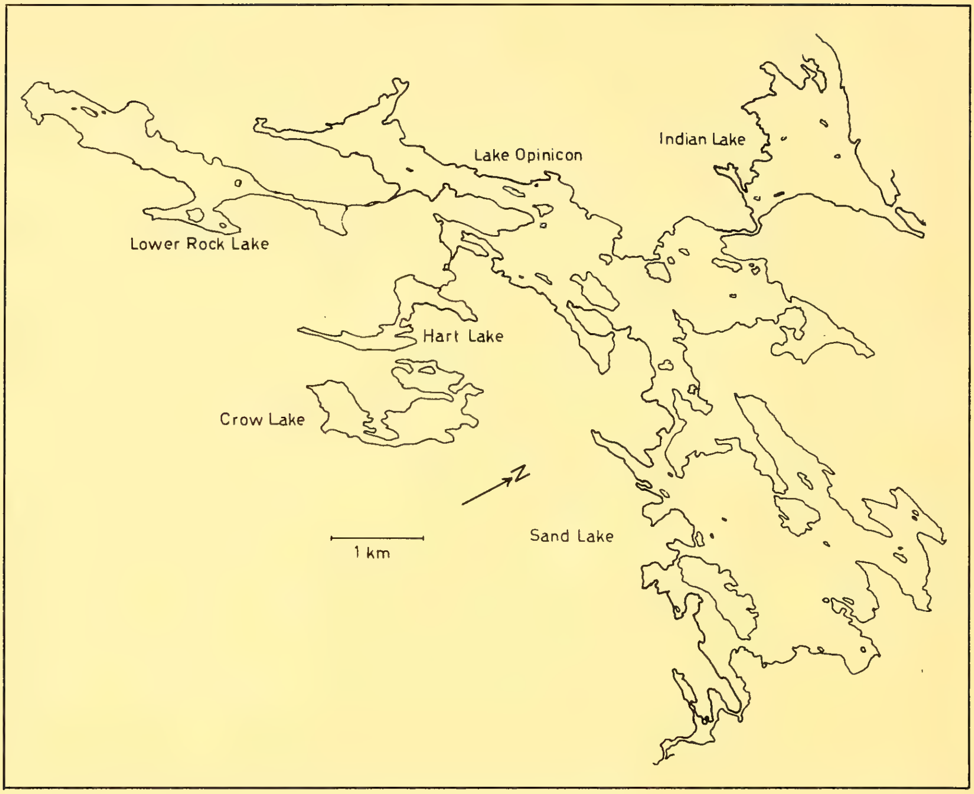

FIGURE 1. Map of the six lakes employed in the study, Frontenac County, Ontario.

Vegetation Analysis

The point-centered quarter method (Cottam and Curtis 1956), with points at 20-m intervals, was used to assess canopy density and tree species composition along a transect through the long axis of each study area. In addition, strip transects (3 × 50 m) perpendicular to the shoreline in each study area were used to determine foliage height diversity (FHD) (MacArthur 1961, 1964) in five vertical layers of vegetation. The amount of edge formed by cottage lots, roads, telephone line cuts, and/or more natural openings, but not including the shoreline, was determined by measuring the length of all edges between forested and open habitat in each study area.

TABLE 1—Scoring scheme for disturbance in three categories

Use category			Score
Roads	Cottages	Boats/hr	
None	None	0	0
Adjacent to study area	Isolated (1 or 2 only)	1–3	1
Through study area	Scattered (several along transect)	4–7	2
	Continuous; ⩾ 25 m between cottages	8–11	3
	Continuous; < 25 m between cottages	12–15	4
		16	5

Bird Censusing

Bird populations of the 25 study areas were censused by the strip transect method (Merikallio 1958; Järvinen and Väisänen 1975; "method D" *in* Emlen 1971). Censuses were conducted by walking 400 m along a transect parallel to and 25 m in from the shore at each study area. Stops of 3–5 min were made every 40 m and all males seen and/or heard were counted. A lateral distance of 25 m on either side of the observers was considered to be the maximum range over which

the quieter birds could be detected as readily as were the more conspicuous ones. All censuses were conducted between 05:00 and 09:30 under favorable weather conditions during the period 17 May to 6 July. Each transect was censused 3 times, once during the first third, once in the middle, and once near the end of this period. The majority of the work was carried out after 23 May in order to reduce the possibility of migrants being included in samples. In addition, equal numbers of disturbed and undisturbed transects were censused early in the season so that the presence of migrants (if any) would have had an equal effect on both types of study area.

Censuses were carried out by two or occasionally three observers, providing a thorough check on species identification. One member of each census team was present during all censuses conducted on any particular transect while the other member(s) varied.

Data on bird species occurrence and relative abundance were used to determine the species diversity for each transect. The diversity index used was the information theory measure H′, in which $-\sum_{i=1}^{S} p_i \log p_i$ where p_i represents the proportion of the total number of individuals that belong to the i^{th} species (Shannon and Weaver 1949). S denotes species richness and refers to the total number of species present. Evenness (J′), which is defined by $J' = H'/\log S$ is a measure of the relative distribution of individuals amongst the species. Both richness and evenness contribute to the relative magnitude of H′. The reader is referred to Pielou (1966, 1975) for derivation of these formulae.

Qualitative observations suggested that the characteristic avifaunas of highly disturbed study areas were different from those of less disturbed plots. To quantify this difference we compared the species composition of each transect to that of the most disturbed transect (Mustard Point on Sand Lake, transect #12) by computing Coefficient of Community (CC) and Percentage Similarity (PS) values (Pielou 1975). These indices estimate the similarity between the avifauna of the Mustard Point area and that of each of the other transects. The Coefficient of Community is defined as $CC = 200S_{xy}/S_x + S_y$ where S_x and S_y are the numbers of species found in each of the two study areas being compared (Mustard Point with each of the 24 others in this case) and S_{xy} is the number of species common to both areas. Percentage Similarity is determined by $PS = 200\Sigma_{\min}(P_{i_x}, P_{i_y})$ where P_{i_x} and P_{i_y} are the quantities of species i on transects x and y expressed as proportions of the total number of all S species in the two study areas combined.

Nesting Success

Nests of Common Loons (*Gavia immer*) located in shoreline areas throughout the study lakes were monitored weekly to determine nesting success. Eastern Kingbirds (*Tyrannus tyrannus*) breeding in shoreline areas commonly build nests in cedar (*Thuja occidentalis*) trees on the water's edge. These nests are frequently less than 3 m above the ground and are often built in branches overhanging the water. Thus, like the nests of loons, they were considered to be particularly vulnerable to disturbance from nearshore boating and/or camping activity. Kingbird nests on the shores of Sand and Opinicon lakes were visited every 3 days until fledging or nest failure occurred. Nests were considered successful if they fledged at least one young. For loons, a breeding attempt was considered successful if any young loons were still alive at the termination of the project on 10 August.

Nests of both species were scored for disturbance with respect to boat use and general activity in the area. The former factor was estimated as described previously. The intensity of human activity was estimated by noting the presence and number of picnic tables, camp sites, and/or cottages within 25 m of the nest. A nest subject to high levels of activity was assigned a score of 3, whereas one in an isolated, uninhabited area scored 1. The total disturbance designation for a nest was the sum of the scores in these two categories. Values ranged from 1 to 8, with nests scoring less than 4 being considered 'undisturbed,' and those with scores of 4 or greater considered 'disturbed.'

All field work for the project was conducted by a five-person team during the period May through August 1976.

Results

Vegetation Analysis

Eighteen genera of canopy trees were found to be present on the 25 transects; 10 of the taxa comprised 95% of all the trees present. No significant difference was found between the average amounts of each genus in disturbed (disturbance level ≥ 3) and undisturbed study areas (Mann-Whitney U-test, $P \geq 0.05$; Table 2). There was no correlation between the abundance of a particular genus on any transect and the bird species diversity, species evenness, or species richness of that transect.

Foliage height diversity (FHD) values were generally lower in disturbed areas although the trend was not significant ($P > 0.05$) (Table 3). A significant positive correlation was found, however, between disturbance and the amount of edge present within a study area (Kendall Rank Correlation, $P \leq 0.05$). The average amount of edge in undisturbed areas was only 188 m compared to a mean of 455 m in disturbed locations. This relationship is not surprising in light of the factors that comprise the disturbance score, as the

TABLE 2—Vegetation composition of disturbed (disturbance) level ≥ 3) and undisturbed study areas: average percentage of total canopy trees on each transect belonging to the 10 most common tree genera

Tree genera	Average per transect (%)	
	Disturbed	Undisturbed
Pinus	23.2	23.2
Acer	17.7	14.2
Quercus	20.8	22.2
Betula	3.8	2.7
Carya	2.6	8.2
Fraxinus	7.9	12.2
Populus	2.4	1.2
Tilia	3.9	7.3
Ulmus	3.1	1.9
Ostrya	5.3	3.7

presence of roads and the number of cottages are both partial determinants of the amount of edge habitat in a study area.

Canopy density (CD) was not significantly correlated with either disturbance or amount of edge, although a general trend toward a decrease in CD with an increase in edge was observed. This result also is as expected: CD values averaged over several sampling points along transects which include extensive edge habitat will likely reflect the reduction in tree density which is implied by the existence of these edges.

Relative Bird Abundance and Species Diversity

The relative abundance of birds in each study area (the total number of birds recorded during the three replicate censuses of each transect) was positively correlated with disturbance (Kendall Rank Correlation, $P \leqslant 0.001$; Table 4). Population densities of birds tend to be greater across ecotones (Kendeigh 1944; Odum 1971); since in this study amount of edge or ecotone was positively correlated with disturbance, bird abundance was examined in relation to the amount of edge in each study area. The number of individual birds in each area was positively correlated with edge as well as with disturbance (Kendall Rank Correlation, $P \leqslant 0.001$). A nonsignificant tendency toward decreasing diversity with increasing development was also indicated: the average H′ for disturbed transects was only 4.053 compared to a value of 4.214

TABLE 3—Structure of the vegetation on each transect: amount of edge, foliage height, and canopy density in relation to disturbance

Disturbance level	Amount of edge (m)	Foliage height diversity	Canopy density (1/m^2)	Transect number
1	0	2.036	0.038	15
1	150	1.884	0.073	1
1	250	1.612	0.051	16
1	300	1.667	0.034	8
2	25	1.893	0.062	14
2	50	1.715	0.022	21
2	75	1.924	0.036	19
2	150	2.049	0.021	22
2	150	1.896	0.033	18
2	200	1.868	0.035	25
2	200	1.594	0.023	23
2	400	1.909	0.038	6
2	500	1.612	0.037	20
3	150	2.011	0.054	10
3	300	1.696	0.006	17
3	700	1.527	0.007	11
4	250	1.746	0.048	5
5	50	1.587	0.087	24
5	110	1.587	0.085	2
7	300	2.126	0.034	13
7	1000	2.043	0.075	9
8	400	1.836	0.064	4
8	800	1.630	0.045	7
9	650	1.445	0.010	3
11	750	0.465	0.005	12

TABLE 4—Avian community characteristics: the bird abundance, species diversity, species richness, species evenness, Coefficient of Community, and Percentage Similarity values for each transect

Disturbance level	Bird abundance (total individuals counted)	H′	*S*	J′	Coefficient of Community (%)	Percentage Similarity (%)	Transect number
1	109	4.371	28	0.909	70.34	57.60	15
1	49	4.027	21	0.917	59.57	20.56	1
1	63	4.334	25	0.933	47.06	26.38	16
1	103	4.022	22	0.902	70.83	34.14	8
2	43	4.344	24	0.947	60.00	22.52	14
2	113	4.426	29	0.911	58.18	42.98	21
2	65	3.904	21	0.889	51.06	24.42	19
2	106	4.271	26	0.909	57.69	36.14	22
2	87	4.022	21	0.911	63.84	35.16	18
2	112	4.270	26	0.909	80.72	70.28	25
2	84	4.105	23	0.907	53.06	32.36	23
2	116	4.474	34	0.879	63.33	41.98	6
2	65	4.214	25	0.907	66.67	28.36	20
3	61	4.094	23	0.905	61.22	29.34	10
3	116	4.118	29	0.862	58.18	47.82	17
3	112	3.958	25	0.852	66.67	55.65	11
4	72	4.048	21	0.922	59.57	31.26	5
5	75	3.933	22	0.882	62.50	29.34	24
5	74	4.035	24	0.880	64.00	36.14	2
7	117	4.096	26	0.871	84.62	82.00	13
7	104	3.759	21	0.856	68.09	73.20	9
8	104	4.277	24	0.933	76.00	56.62	4
8	143	4.136	28	0.860	74.07	73.24	7
9	169	4.103	24	0.895	72.00	95.60	3
11	156	4.079	26	0.868	100.00	100.00	12

for more isolated areas.

When the two components of species diversity were examined separately, species richness was not correlated with disturbance, amount of edge, FHD, or canopy density. The evenness component (J′), on the other hand, was significantly and negatively related to disturbance and amount of edge (Kendall Rank Correlation, $P \leq 0.01$).

Coefficient of Community and Percentage Similarity values relative to the highly disturbed Mustard Point transect were positively correlated with disturbance (Kendall Rank Correlation, $P \leq 0.01$; Table 4). In effect, the more disturbed an area, the closer the species composition of its avifauna resembled that of Mustard Point. In general, species common in urban areas, such as American Robins (*Turdus migratorius*), were found more frequently and in greater abundance in disturbed study areas. In contrast, other species such as Blackburnian (*Dendroica fusca*), Cerulean (*D. cerulea*), and Black-and-White (*Mniotilta varia*) Warblers were found more commonly or only in undisturbed areas. This was illustrated not only by the PS and CC values, but also by a comparison of disturbed and undisturbed transects with regard to the distribution of the 20 most common species (Table 5).

Nesting Success

Common Loons nesting in undisturbed areas appear to have had higher success than those nesting in disturbed locations. Although the sample size is too small for statistical testing, four out of six nests with low disturbance scores (< 4) fledged at least one young, while in disturbed areas only two out of seven nests were successful.

The same trend is apparent for Eastern Kingbirds. Nine of 13 nests in undisturbed areas were successful, while only 5 out of 13 nests in disturbed areas fledged any young. A larger percentage of the total number of eggs laid hatched in undisturbed than in disturbed locations (73.8% vs. 53.6%; chi-square test, $P \leq 0.10$). Nests in undisturbed areas produced significantly more fledglings as a proportion of the total number of eggs laid than did nests in disturbed areas (50% vs. 25%; chi-square test, $P \leq 0.05$). There was no differ-

TABLE 5—Distribution of the 20 most common bird species. Ci-square test; $*P \leqslant 0.05$, $**P \leqslant 0.005$

Species	No. in disturbed study areas	No. in undisturbed study areas
Molothrus ater	142	113
Melospiza melodia	91	80
Vireo olivaceus	63	85
Turdus migratorius	111	28**
Spizella passerina	75	64
Icterus galbula	72	50*
Spinus tristis	31	60**
Dendroica petechia	74	15**
Vireo gilvus	69	15**
Contopus virens	43	28
Parus atricapillus	29	38
Myiarchus crinitus	16	47**
Troglodytes äedon	60	2**
Tyrannus tyrannus	41	18**
Quiscalus quiscala	28	29
Bombycilla cedrorum	32	20
Dendroica pinus	27	22
Setophaga ruticilla	10	34**
Piranga olivacea	12	29*
Mniotilta varia	1	37**

ence in mean clutch size between the two habitat groups.

Discussion

Nesting Success

A variety of factors might be responsible for the reduced nesting success of kingbirds and loons in disturbed areas. Human activity (e.g., fishermen, picnickers) was observed to frighten birds off their eggs during incubation. Such repeated disturbance could result in chilling of the eggs or nestlings or increased exposure of the nest to predators. Also the increased abundance of Raccoons (*Procyon lotor*) and Eastern Chipmunks (*Tamius striatus*) often associated with human disturbance (i.e., with garbage cans and picnic areas) might result in greater predation of nests in such areas. In addition, located as they are on the ground close to the water's edge, loon nests are often vulnerable to waves caused by large watercraft such as those which travel the Rideau Waterway (cf., Vermeer 1973).

The abundance, larger clutch size, and broad habitat distribution of kingbirds reduces the likelihood that reduced nesting success in disturbed shoreline areas will appreciably affect their population size. For loons, with many fewer nests per lake, the risk is much greater that some factor resulting from disturbance could, over a period of years, eliminate the entire population of an area. These birds show a strong attachment to their nesting site, returning to it year after year, even after repeated failure (Bent 1919; Webb 1963). The disappearance of loons from several Rideau lakes on which they had nested previously and a decline in the number of nesting pairs on other lakes has been noted by several authors (e.g., Quilliam 1973). The absence of breeding loons from some of the densely populated lakes in Minnesota (Ream 1976; personal observation) may be further evidence of the vulnerability of this species.

Edge Effect, Bird Species Diversity, Species Composition

An edge or ecotone is essentially a transition zone between two different habitat types. Such a zone commonly contains some species found in each of the adjoining habitats as well as others characteristic of the ecotonal region itself. As a result, both population density and species richness may be increased in the vicinity of an edge (Pianka 1974). Examples of changes in community structure occurring as a result of an increase in edge are abundant, particularly for avian communities (e.g., Beecher 1942; Odum and Burleigh 1946). In the present investigation, however, species richness and/or diversity were not found to be higher in study areas that possessed increased amounts of edge, despite the greater number of individual birds observed to occur in these locations. This suggests that the edges formed as a result of cottage development are different in some respects from edges formed in other ways, such as between forest and field. They thus may not serve as interfaces between two habitats, both of which are capable of sustaining diverse avian communities; rather, they may be boundaries between wooded areas capable of supporting many avian species and developed (i.e., built up, cleared of much vegetation) spaces used by only a few hardy types. Thus, although the creation of this type of edge may typically influence certain aspects of the avian community (e.g., species composition, population abundance), its effect on other parameters (e.g., species diversity, species richness) may be minimal, quite different from that which might have been predicted on the basis of previous studies of edge habitat.

Past studies have shown that the substitution of edge habitat for portions of climax forest may result in the dislocation of many 'true forest' species (see Kendeigh 1944). Perhaps out-competed by those that preferentially inhabit such ecotones, or faced with detrimental changes in certain habitat variables, these forest species may withdraw into more isolated tracts of woodland. In our study several typically forest-dwelling species including the Yellow-billed Cuckoo (*Coccyzus americanus*), Yellow-throated Vireo (*Vireo*

flavifrons), Black-and-White and Cerulean Warblers, American Redstart (*Setophaga ruticilla*), and Pileated Woodpecker (*Dryocopus pileatus*) were more abundant in, or restricted to, the less disturbed transects which were characterized by reduced amounts of edge.

On the other hand, land development may result in an influx of other species more characteristic of open areas. For example, the construction of buildings on portions of this land provides conditions suitable for those birds that commonly nest in or around such structures (e.g., Barn Swallows, *Hirundo rustica* and Eastern Phoebes, *Sayornis phoebe*). The expected influx of new species as a result of such events may not be sufficient to outweigh the desertion of disturbed habitats by other species. Thus species richness and/or diversity might be expected to remain the same or even decline in areas where the cause of an increase in edge habitat is cottage development rather than some other factor. Such a trend is indeed indicated by our data.

The increase in edge on disturbed transects resulted in a few species being favored. For these characteristic edge species (e.g., American Robins and Northern Orioles, *Icterus galbula*), population densities rose to very high levels in disturbed areas, while for other species densities were the same as or less than they were in undisturbed locations. Consequently, the evenness with which individuals were distributed among species was reduced in disturbed areas. The decrease in average H′ noted for transects with disturbance levels $\geqslant 3$ may thus have been due to a reduction in J′, since S remained fairly constant.

It is apparent from the data, and for the reasons discussed above, that the major effect of disturbance in the areas investigated has been on the actual species composition of the avian fauna. This is indicated by the PS and CC values in particular. The extent of land development on Mustard Point approached that of an urban or suburban situation; the abundance of buildings, the presence of two roads, and extremely high levels of boat traffic in the area were reflected in very low values for FHD, CD, H′, and J′. The difference between the avifaunas of Mustard Point and those of the majority of other transects is an indication of the nature and extent of the influence that intensive land development can have on a once natural landscape. It is worthy of note that the only Rock Doves or domestic pigeons (*Columba livia*) observed during the study were seen on Mustard Point.

This investigation was conducted in an area in which land development, although extensive, is not generally as intensive as in some other recreational centers. Extreme habitat alteration such as on Mustard Point is rare on these lakes. Thus, although some canopy trees have been removed when cottages and roads were built, many remain, and much of the understory vegetation has been left untouched or replaced. This type of land use is in contrast to that encountered on many of the more populated lakes in Ontario and elsewhere: often several tiers of cottages extend back from the shoreline, lawns are manicured, and only scattered canopy trees remain. In the Rideau Lakes region, such high intensity land use fortunately continues to be rare.

Our results are thus generally indicative of a low level of disturbance, as might have been predicted. A magnification of the noted effects may be expected in situations of more intensive development. The results point to the need for further study as well as for careful planning and control to prevent higher intensity use from having seriously deleterious effects on breeding bird populations.

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Soil-site Characteristics of Kentucky Coffeetree (*Gymnocladus dioica*) Communities near Lake Erie

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Five distinct Kentucky Coffeetree (*Gymnocladus dioica*) communities near the southwest shore of Lake Erie were studied. Here the coffeetree is restricted to excessively drained, coarse sandy beach ridges of Recent origin. The soil profiles are shallow, contain low amounts of organic matter, and have a porous gravelly horizon in the subsoil. All the sites are sloped east by northeast. These locations add to the knowledge of soil-site characteristics of the Kentucky Coffeetree and expand knowledge of its environmental range.

Key Words: *Gymnocladus dioica*, Kentucky Coffeetree, site characteristics, soil factors, plant communities.

The relationship between vegetation pattern, including both species and community types, and edaphic factors represents an important area of ecological concern. A detailed study of edaphic controls of tree species distribution in presettlement Indiana indicated that for tree species in general the most influential soil attributes are profile depth, nitrogen content, and clay content (Cranshaw et al. 1965). Similarly, 36 hardwood stands in Indiana were studied and correlations were recognized between tree species and drainage profiles, available moisture, permeability, texture of the A horizon, source of parent materials, pH of the B horizon, and degree of development of the soil (Schmelz and Lindsey 1970).

Vegetation responds to variations in soil properties, especially soil moisture. Soil moisture influences other soil properties, which in turn have an effect on plant community and plant species distributions. Little is known of the site characteristics or habitat of the Kentucky Coffeetree (*Gymnocladus dioica*). The tree has received little recognition in Canada despite being reported as early as 1710 (Fox and Soper 1953).

The Kentucky Coffeetree is a rather rare tree (Department of Interior 1933; Gleason 1952; Zavitz 1959; Department of Forestry 1961; Preston 1966), not often found in the natural setting (Medsger 1939; Deam 1940; White 1968). More often it is planted as an ornamental tree ranging from central New York, southern Ontario, and southeast South Dakota to Virginia, Tennessee, and west to Oklahoma (Petrides 1958; White 1968). The range in southern or southwestern Ontario (United States Forest Service 1953; Department of Forestry 1961; Peattie 1966) is concentrated in the Lake Erie zone or the borderlands of Lake Erie and Lake Ontario (Zavitz 1959) from Niagara Falls westward to Lake St. Clair (Department of Interior 1933). Macoun (1883) verified a number of large Kentucky Coffeetree specimens on the north end of Pelee Island in Lake Erie; however, he also expanded the range north to Point Penetanguishine, Ontario. Hamilton (1943) cited specimens in Dufferin County west of Lake Simcoe. It is difficult to say whether Macoun's and Hamilton's examples include natural or planted specimens because other studies indicate planted coffeetrees in Ottawa (White 1968) and Montreal (Keeler 1920).

Soper (1956) and Fox and Soper (1953) conclude that the Kentucky Coffeetree is a genuine component of the native flora in Canada only in the western portion of Ontario where they recorded it from Pelee, Hen, East Sister, and Middle Sister islands in Lake Erie and cited specimens near Petrolia and southwest of Florence. A dense stand near Mitchell Bay on Lake St. Clair was included as a sight record. Core (1948) considered the coffeetree common on a number of the Lake Erie islands but noted that it was seen on Pelee Island in 1882 (from Macoun 1883) but not seen in 1912. The most recent study (Hosie 1973) limits the natural range to areas near Lake St. Clair and Lake Erie in extreme southwestern Ontario. Lake Erie and its predecessors seem to have functioned as a significant barrier to the migration of distinctively Carolinian species, such as the Kentucky Coffeetree, into the Ontario flora (Pringle 1979). The tree seems to have entered around the western end of the lake and have spread naturally little farther.

The species is found as scattered individuals (Department of Forestry 1961) or as isolated stands. Except at Mitchell Bay, generally only solitary trees are found in extreme southern Ontario, which assumes that the tree is vulnerable as germinating seeds or young seedlings to present-day climatic conditions (Pringle 1979).

Thus, mature trees survive for many years but rarely does a seedling make it past the vulnerable years to add new trees to the woodlands. Therefore, areas where stands do occur represent important locations in which to study the site characteristics of the species.

The Kentucky Coffeetree prefers fertile, moist, loam-textured soils in open woods, especially bottomlands along streams (Keeler 1920; Department of Interior 1933; Medsger 1939; Deam 1940; Gleason 1952; Harlow 1957; Petrides 1958; Grimm 1962; Harrar and Harrar 1962; Steyermark 1963; Oliver 1965; Sargent 1965; Peattie 1966; Preston 1966; Morley 1969; Li 1972). It is a fast-growing medium-sized to rarely large tree which is site-specific and intolerant of competition factors, especially shade (Braun 1961; Harrar and Harrar 1962; Oliver 1965; Preston 1966; Otis 1970; Wharton and Barbour 1973). The tree is frequently found on limestone soils, especially in Ohio and Kentucky (Braun 1961; Peattie 1966; Wharton and Barbour 1973).

The Kentucky Coffeetree has, however, been found occasionally on poorer soils as a result of transplanting (Harlow 1957), or on drier soils (Harrar and Harrar 1962). Steyermark (1963) includes sites at the base of bluffs in the range of the tree. The purpose of this paper is to document our investigation of natural Kentucky Coffeetree communities and thus to add to the knowledge of the soil-site characteristics of the species.

Study Area

Our study was carried out at the Davis-Besse Nuclear Power Plant site on the southwest shore of Lake Erie, about 35 km E of Toledo, Ohio (Figure 1). Part of the property is known as Navarre Marsh, a wetland rich in wildlife, within which are a series of superimposed recent beach ridges developed along former shorelines of Lake Erie separating the shallow water of the marsh from the open lake. The beaches contain a number of plant communities which, except along the immediate present shoreline, are protected from storm damage or wave erosion and thus have developed a measure of stability with the local environment.

Five Kentucky Coffeetree communities occur in natural sites in the low back beach area between the lake and the marsh (Figure 2). No location on the back beach is more than 4 m above the present water level and yet the area is protected from the open lake by other beach ridges. There are several backwater lagoons and occasional water areas interspersed among the superimposed beaches creating a series of sloping sites from the beach ridges to the adjacent lagoons. Each of the five Kentucky Coffeetree communities appears to occupy one of these sloping beach ridge sites. The feature of the communities which attracted our attention was their apparent dry beach ridge site specificity, in contrast to the site characteristics stated in previous studies.

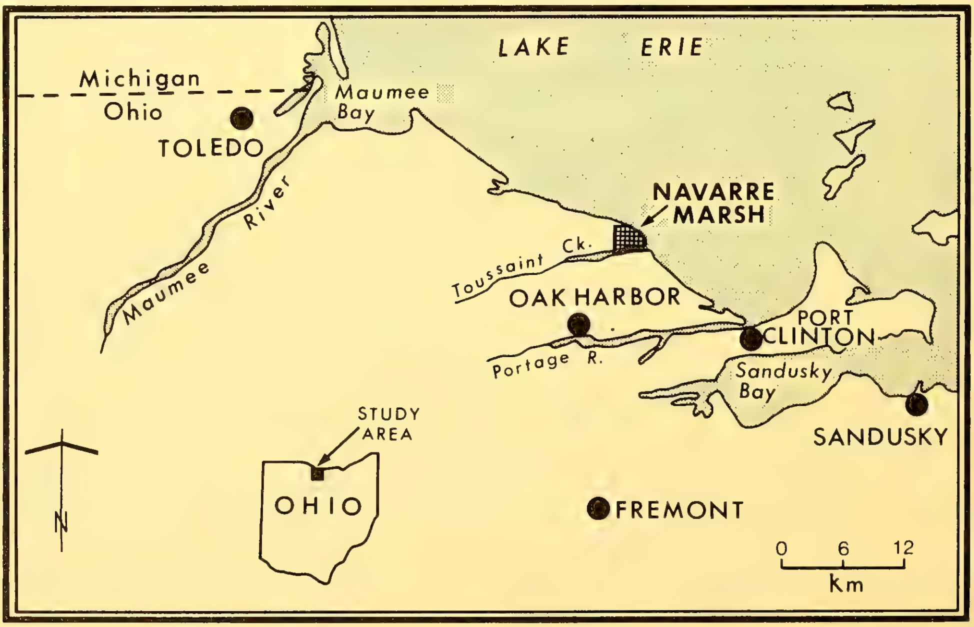

FIGURE 1. Location of study area in Ohio showing surrounding cities (closed circles) and major streams.

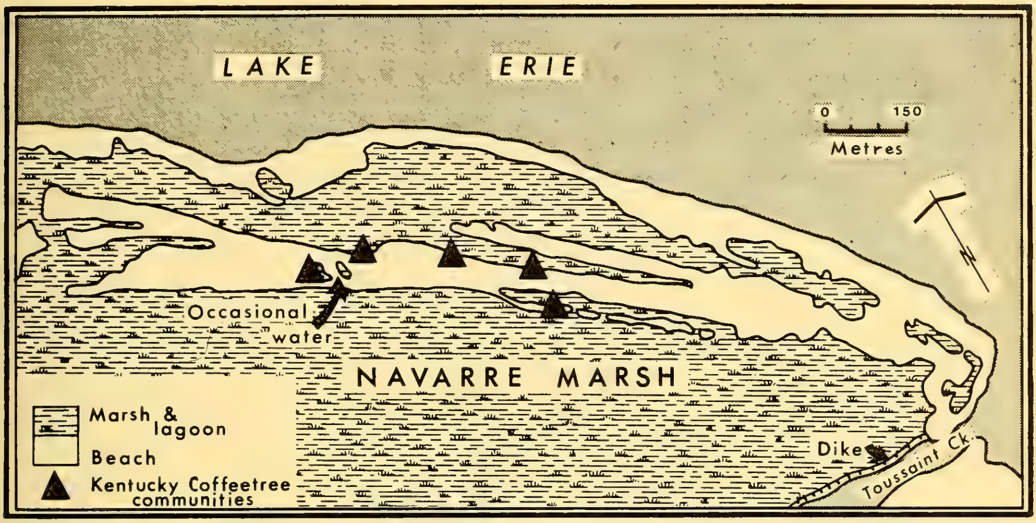

FIGURE 2. Sites of Kentucky Coffeetree communities in Navarre Marsh area near Lake Erie showing the position of the communities relative to marsh or lagoons.

Methods

To describe the Kentucky Coffeetree communities in the Navarre Marsh area quantitatively, we measured all individual trees greater than 2.6 cm in diameter at breast height (DBH) and located them on enlarged aerial photographs. Once the extent of the communities was determined, baselines were surveyed along the longest dimension of each community and quadrats measuring 10 × 10 m were set up along each baseline. Two quadrats were established in each of the five communities and in each of five adjacent tree communities (total of 20 quadrats). Density, frequency, and dominance (average basal area) were calculated for all tree species encountered for the 10 Kentucky Coffeetree quadrats and for the 10 adjacent quadrats.

In addition, nested 4 × 4 m and 0.5 × 2 m quadrats were located within each of 10 × 10 quadrats. The 20 quadrats, 4 × 4 m, were used to count saplings between 0.65 and 3.00 m in height and all shrubs by species. Density, frequency, and relative density and frequency values were calculated for each species. Woody seedlings and herbaceous species were counted in 20 quadrats, 0.5 × 2 m. Density, frequency, cover, and relative values were calculated for each species. Importance values (i.v.) were calculated for all species in all layers as follows: 10 × 10 quadrats — relative density, relative dominance, and relative frequency were summed and divided by 3; 4 × 4 quadrats — relative density and relative frequency were summed and divided by 2; 0.5 × 2 quadrats — relative density, relative frequency, and relative cover were summed and divided by 3.

Three soil cores were dug in each of the twenty 10 × 10 quadrats. The cores were utilized to determine the thickness of A_1 and A_2 horizons, depths to coarse beach gravels, and water table, organic matter content of A_1 and A_2 horizons, mean pH of the combined A_1 and A_2 horizons, and textures of A_1 and A_2 and beach gravel horizons. These soil characteristics were compared between the Kentucky Coffeetree quadrats and the adjacent tree community quadrats. Soil pH was determined by the method of Peech (1965), organic matter by the Walkley and Black method (1965), and texture by the method of Day (1965). Slope percent and direction were calculated for each 10 × 10 m quadrat using a level and rod measurement (Schwab et al. 1957) and a Brunton compass.

A simple one-way analysis of variance test was applied to the vegetation and soils data to determine similarities and differences among the Kentucky Coffeetree communities and between these five communities and the five adjacent tree communities.

Results

Community Composition

At present the canopies of the Kentucky Coffeetree communities in the study area are relatively open, similar to those previously described by others (Braun 1961; Harrar and Harrar 1962; Steyermark 1963; Otis 1970; Wharton and Barbour 1973). Analysis of variance indicates that the five Kentucky Coffeetree

communities are very similar in the relative frequency, relative dominance, and relative density of the tree. The Kentucky Coffeetree is much more important than any other tree species in the canopy layer (Figure 3); other trees are of minor significance (Table 1). Frequency seems to be the most influential factor in the tree layer; larger numbers of trees contribute much more to the importance value than do the size of individual trees. Hackberry (*Celtis occidentalis*) and Dogwood (*Cornus drummondi*) are the dominant tree species in the five adjacent tree communities, with Red Ash (*Fraxinus pennsylvanica*) and Honey Locust (*Gleditsia triacanthos*) of less importance (Table 1). Both Kentucky Coffeetree and Honey Locust are members of the family Leguminosae and are thus closely related.

The frequency of the Kentucky Coffeetree is high in the 4 × 4 quadrats; however, the tree appears to be suppressed in the sampling layer as Choke Cherry (*Prunus virginiana*) and Honeysuckle (*Lonicera tatarica*) are more important (Figure 4). Bladdernut (*Staphylea trifolia*) also is a relatively important tree. Many dead Kentucky Coffeetree saplings in the study sites indicate that its importance may decline in the future. Dogwood and Hackberry are the dominant tree species in the adjacent quadrats. Choke Cherry, Honey Locust, Red Ash, and Kentucky Coffeetree are of minor importance in these adjacent communities in the sapling layer. The Kentucky Coffeetree has a somewhat greater density than the other species of minor importance, but is present in only two of the adjacent tree communities.

In the 0.5 × 2 quadrats Bladdernut, Choke Cherry, and Hackberry are the important tree species. The

FIGURE 3. Domination of canopy by Kentucky Coffeetree showing the lack of other trees larger than 2.6 cm DBH in the canopy layer.

TABLE 1. Community composition with importance values of woody species. Kentucky Coffeetrees (*Gymnocladus dioica*) dominate in the canopy layer (10 × 10 quadrats) but importance decreased in the sapling layer (4 × 4 quadrats) and the trees are absent in the reproductive layer (0.5 × 2 quadrats) of the coffeetree quadrats. Kentucky Coffeetrees lack importance in the adjacent quadrats

	Importance values in quadrats		
Species	10 × 10 m	4 × 4 m	0.5 × 2 m
Coffeetree quadrats			
Gymnocladus dioica	46.8	20.6	0.0
Celtis occidentalis	4.5	—	7.2
Fraxinus pennsylvanica	3.9	—	—
Prunus virginiana	3.0	25.9	11.8
Gleditsia triacanthos	4.5	—	—
Prunus serotina	6.5	—	—
Rhus typhina	2.2	—	—
Lonicera tatarica	2.2	23.5	—
Parthenocissus quinquifolia	—	7.6	30.9
Staphylea trifolia	1.8	6.5	20.2
Ribes americanum	—	5.8	6.1
Rubus occidentalis	—	10.5	9.9
Rhus radicans	—	—	10.1
Adjacent quadrats			
Gymnocladus dioica	0.8	1.7	0.0
Celtis occidentalis	48.1	5.0	14.1
Cornus drummondi	29.9	60.6	22.7
Fraxinus pennsylvanica	12.2	1.3	1.0
Prunus virginiana	2.4	1.2	2.4
Gleditsia triacanthos	6.5	1.2	1.0
Prunus serotina	—	—	—
Rhus typhina	—	—	—
Lonicera tatarica	—	—	—
Parthenocissus quinquifolia	—	4.6	32.6
Staphylea trifolia	—	—	—
Ribes americanum	—	5.4	6.1
Rubus occidentalis	—	18.6	9.9
Rhus radicans	—	—	10.0

FIGURE 4. Open nature of the Kentucky Coffeetree communities showing the lack of good regeneration in the sapling and seedling layers.

Kentucky Coffeetree is unimportant (i.v. = 0.0) in the seedling layer, indicating the suppressed status of the species. Dogwood, Hackberry, and Choke Cherry are the important tree species in the adjacent 0.5×2 m quadrats. The Kentucky Coffeetree is unimportant in the seedling layer, indicating suppression in the adjacent communities as well.

The vegetation data demonstrate that the Kentucky Coffeetree may be a dominant species in a successional stage leading to a stable beach ridge community, but it probably will be replaced by Dogwood and Hackberry as in the adjacent communities. Choke Cherry also appears to be of importance, as communities are found near each of the Kentucky Coffeetree communities identified and studied. Eventually the Kentucky Coffeetree will lose out to trees capable of regeneration in their own shade (Preston 1966; Otis 1970). Despite these predicted changes, some distinguishing soil-site characteristics appear to be specific to the Kentucky Coffeetree.

Soil-site Characteristics

The slope angle and slope aspect of the five coffeetree communities are similar among the quadrats studies (analysis of variance, $P > 0.05$). The slope averages 7.9% with a majority (70%) of the slopes within 1% of the average. In each case, the slope is east by northeast (Figure 5). The direction of slope varies within only 5° of the true compass ENE direction. In each case, the slope opens onto a low lagoon or occasional water area (Figure 6). The most striking feature of the sites is the openness or lack of canopy in the ENE direction in all five communities. In contrast, the slope angle of the five adjacent tree communities averages 1.5% with no dominant slope aspect. A sloping site adjacent to open marshland or bottomland is a distinguishing site characteristic.

Soil profile characteristics for the surface and subsurface horizons seem to be similar between the Kentucky Coffeetree and adjacent communities (Table 2). The presence of weakly developed A horizons and the lack of B horizons classifies the soils as Orthic Humic Regosols (Typic Udipsamments). The A horizon has been subdivided into A_1 and A_2 horizons based on color and organic matter content. The average texture of the A_1 horizon (medium sand) and the A_2 horizon (medium to medium-coarse sand) is similar for all the communities studied.

A very coarse-textured horizon is found below the surface and subsurface horizons in each of the profiles sampled in the Kentucky Coffeetree communities. The very coarse sand, gravel, and shell fragments in this IIC horizon are extremely porous, allowing each site to be excessively drained. At the comparable depths in the profiles of the adjacent tree communities, the texture averages medium sand, the C horizons

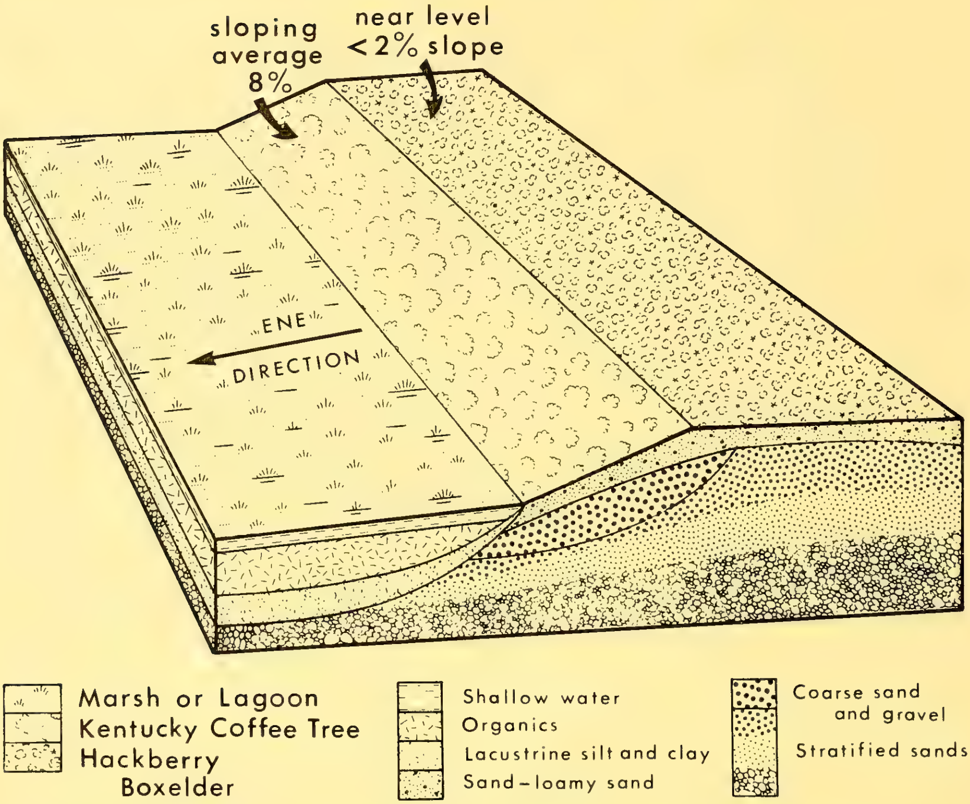

FIGURE 5. Site characteristics of Kentucky Coffeetree communities showing the average site conditions of the communities and the underlying gravel layer.

contain no gravel or shell fragments, and the porosity allows the sites to be well drained. The consistent presence of the coarse sand and gravel IIC horizon is a significant feature in the coffeetree communities and a distinguishing site characteristic for the Kentucky Coffeetree in the study area because no other areas on the beach have horizons so coarse.

The depth of the summer water table and the apparent fluctuation in the water-table depth are consistent within the Kentucky Coffeetree communities. Seventy percent of the core samples are within 5 cm of the average depth. The small vertical distance of mottling above the summer water table indicates a relatively stable water table and a well drained location because of the depth of water. The well to excessively well drained soil with mottling only deep in the profile is common both to the Kentucky Coffeetree communities and to the adjacent tree communities and cannot be considered a distinguishing feature of the Kentucky Coffeetree communities.

The amount of organic matter in the A_1 and A_2 horizons is consistent in the five Kentucky Coffeetree communities; 90% of the samples group within 0.3% of the average. The A_1 horizon has a moderate organic matter content and the A_2 horizon has a moderately low organic matter content (Table 2). The organic matter content in the adjacent communities is significantly higher. Relatively low organic matter content is a distinguishing feature of the Kentucky Coffeetree communities in the Navarre Marsh area.

The pH values for the soil samples in all the communities studied show that soil conditions are near neutral (Table 2). The near neutral pH is characteristic both of the Kentucky Coffeetree communities and of adjacent tree communities.

Discussion

The Kentucky Coffeetree dominates the canopy level in each Kentucky Coffeetree community, but seems incapable of surviving well in its own shade, as described in previous studies (Harrar and Harrar 1963; Otis 1970; Wharton and Barbour 1973), and thus is being suppressed in the sapling layer and is absent in the seedling layer. The openness of the site,

FIGURE 6. Coffeetree Community looking northwest showing the slope from left to right with the open marsh to right.

especially ENE, further supports the light requirement characteristic of the species. No other tree species seems to dominate these specialized ENE slope positions in other parts of the study area.

Several soil-site characteristics are consistent for all five of the Kentucky Coffeetree communities investigated and are significantly different from the adjacent tree communities. The sloping site characteristics appear to add a new dimension to the previous site descriptions. Steyermark (1963) located the Kentucky Coffeetree at the base of slopes rather than on the slope face as on the beach ridges of this study. The excessively well-drained sands of the beaches is similar in soil type to the well drained terraces of Deam (1940) and the possible habitats in the drier sites of Harrar and Harrar (1962) and Harlow (1957). The dry site characteristic expands on the moist bottomland sites described in several previous works (Grimm 1962; Preston 1966; Li 1972).

The presence of a coarse sand and gravel horizon and a relatively shallow profile above the coarse horizon tends to contradict the descriptions of the

TABLE 2. Similarities and differences in soil-site characteristics between the Kentucky Coffeetree quadrats and the adjacent quadrats

Characteristics	Coffeetree quadrats			Adjacent quadrats		
	High	Low	Average	High	Low	Average
Slope angle (%)*	13.1	5.2	7.9	2.0	0.0	1.5
Thickness (cm) A_1 horizon	9.8	19.2	15.0	12.0	24.0	15.8
Thickness (cm) A_2 horizon	7.2	14.4	10.0	7.2	14.5	10.1
Depth (cm) to coarse layer*	65.0	24.0	42.0	—	—	—
% organic matter A_1*	5.0	3.5	3.7	9.0	6.2	7.7
% organic matter A_2*	2.5	1.5	1.9	7.4	4.4	6.1
Combined pH value A_1, A_2	7.5	6.5	6.8	7.5	6.5	6.8
Water table depth, cm	121	87	98	110	79	91
Thickness (cm of mottling above summer water table)	10.0	5.0	7.5	10.0	5.0	7.5

*These characteristics are significantly different between the coffeetree and adjacent quadrats using an analysis of variance test. The probability of both groups of samples coming from the same population is less than 5% ($P < 0.05$).

preference of the tree for deep loamy soils (Grimm 1962; Oliver 1965; Peattie 1966). The relatively low organic matter content of the soils tends to be counter to the descriptions of rich or fertile soils which give the connotation of high organic matter levels (Grimm 1962; Harlow 1957; Harrar and Harrar 1962; Peattie 1966; Petrides 1958; Sargent 1965).

The near neutral pH values for the soils supports the previous indications of a preference for limestone soils (Braun 1961; Peattie 1966; Wharton and Barbour 1973).

Factors in the response of tree species to environmental conditions include not only the narrow ecological optimum where the species respond vigorously to optimum conditions, but also the tolerance limits or range of conditions under which the species can exist (Kellman 1975). The Kentucky Coffeetree perhaps has an optimum set of conditions which have been described adequately in previous works. This study enlarges on the optimum conditions to show that site characteristics may also include coarse-textured sandy to gravelly soils, excessively well drained sites, relatively infertile soils, sloping sites, and shallow to moderately shallow young soils such as those found in common among the five communities of the Navarre Marsh. In the Navarre Marsh area the tree does not grow except in the habitats implied by these site characteristics.

All five of the coffeetree communities are similar: soil profiles, importance values with the dominating frequency in the tree layer, the slope grade, the slope direction, the openness of the site, and the excessively drained soil character. The tree definitely is found not only on bottomlands or in moist woodlands, and such site specificity should be re-evaluated.

It is possible that earlier site descriptions misinterpreted the habitats of Kentucky Coffeetree communities because the tree is found near moist lowland sites in the study area, the adjacent lagoons of the back beach environment. It would be easy to include well drained river levees or well drained bottomland gravel bars as part of a "moist bottomland" site description.

Perhaps the key factor to site specificity for the Kentucky Coffeetree is recently developed soils. The bottomland soils along streams are soils developed from recent alluvial deposits and the beach ridge soils of the Navarre Marsh are soils recently developed at the margin of a lacustrine environment. Perhaps drainage, slope angle, slope direction, texture of soils, and depth of soil profile may be secondary to the age of the soil parent material in determining the presence of the Kentucky Coffeetree. This study broadens the soil-site amplitude of the Kentucky Coffeetree and proves that there are variations to the range of the species.

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Aggregation Behavior of Wapiti (*Cervus elaphus*) in Riding Mountain National Park, Manitoba

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Analyses of 1500 ground observation reports involving 6700 Wapiti (*Cervus elaphus*) for the 1971–1974 period were based on annual, seasonal, and monthly mean group sizes and ranges for all groups, male only groups, antlerless aggregations, and mixed-sex associations. These showed that group sizes are extremely variable for antlerless aggregations at all times, male groups show significant variations seasonally, and mixed-sex aggregations are numerous during fall. Grouping behavior follows a seasonal sequence from smallest means in summer to greatest means in late fall and early winter. Behavior in this flatland herd in Riding Mountain National Park, Manitoba differs from that in mountain populations by showing less marked seasonal variations and absence of spring migratory aggregation.

Key Words: Wapiti, aggregation behavior, Manitoba, Riding Mountain National Park, Elk, seasonal variations, population density.

Grouping behavior in ungulates is related to environmental change and physiological function. Particularly important are weather conditions, vegetative cover, and consequent seasonal variation in food supply (Moran 1973). Physiological factors affecting aggregation include sex of the animal, breeding, calving, and rearing of young. Defense against predation and migration also may affect grouping behavior (Tinbergen 1953; Peek et al. 1974).

This research assesses the grouping behavior of Wapiti (*Cervus elaphus*) in Riding Mountain National Park, Manitoba. The Wapiti are a remnant indigenous population and the largest of the few herds that exist outside of the western cordillera of North America. Wapiti populations within the park fluctuated between 2000 and 6000 animals between 1950 and 1976, and aerial surveys during the study period resulted in estimates of 6200 in 1971, 3000 in 1973, and less than 2000 in 1974 (Rounds 1977). The study area was described previously (Rounds 1977, 1978). The purposes of this research were to ascertain whether aggregation behavior in a remnant flat-land population of Wapiti differs from that in herds in mountainous terrain as reported by Altmann (1952, 1956), Boyd (1970), Knight (1970), and Murie (1951), and to elucidate factors affecting the grouping characteristics of the Riding Mountain herd.

Methods

Park wardens, professional naturalists, and I recorded sex and age composition of groups whenever possible between 1971 and 1974. Adult sex identification was reliable for most months because males usually retained antlers through March and new growth was evident by May. Calves (young-of-the-year) and yearling females were often difficult to distinguish from adults; consequently, they were included under the designation "antlerless." Yearling males (spikes) were considered adult males if they occurred either alone or with other adult males. Aggregations in which sex and age of all animals were identified were considered in the analyses (Boyd 1970). Aerial surveys in February and December 1974 and January 1975 provided comparative information on sex and age composition and size of groups. With these survey methods, it was possible to identify the age and sex of most observed Wapiti (Rounds 1977).

A group was defined to allow for single animals; the words group, aggregation, and association are used interchangeably. Data were reduced to annual, seasonal, and monthly mean group sizes for all Wapiti, and annual and seasonal mean group sizes for sex-separated associations. Analysis of variance was employed to ascertain significance among means, with the Tukey test used to discern means indicated as divergent ($P < 0.05$) (Games 1978).

Systematic weather data are not available for Riding Mountain, but records from nearby stations adjusted by short-term information from several locations within the park indicated that winter snowfall averages 90–100 cm and maximum accumulation averages 55–60 cm. Mean values of maximum snow accumulations kept at warden stations during the study period were as follows: 1971, 31 cm; 1972, 38 cm; 1973, 36 cm; 1974, 72 cm.

Results

Means for group size of Wapiti remained nearly constant for the first 3 yr for all observations in spite of changes in the number of reports, number of Wapiti reported, and estimated total populations (Table 1). Although the 1974 mean of 3.5 Wapiti per group was

TABLE 1—Number of individuals and mean and maximum numbers in a group by month, season, and year for Wapiti in Riding Mountain National Park, 1971–1974. In each case the minimum number in a group was 1

	All years			1971			1972			1973			1974		
	Total	Group		Total	Group		Total	Group		Total	Group		Total	Group	
Month	indiv.	Mean	Max.	indiv.	Mean	Max.	indiv.	Mean	Max.	indiv.	Mean	Max.	indiv.	Mean	Max.
Jan.	948	4.1	37	318	4.2	25	304	3.9	37	156	4.6	30	170	3.8	30
Feb.	613	3.9	33	124	4.4	25	237	3.6	24	186	7.2	33	66	1.8	5
Mar.	338	3.9	50	57	3.0	18	155	4.6	19	89	8.1	50	37	1.7	6
Winter	1896	4.0	50	499	4.1	25	696	3.9	37	431	6.1	50	270	2.6	30
Apr.	300	4.4	67	57	5.7	12	59	3.1	9	114	8.1	67	70	2.7	10
May	367	3.0	15	74	3.2	14	52	2.2	8	147	4.2	13	94	2.4	15
Jun.	251	3.1	17	54	2.7	10	116	5.0	17	40	2.1	9	41	2.1	7
Spring	918	3.4	67	185	3.5	14	227	3.4	17	301	4.4	67	205	2.4	15
Jul.	177	4.1	35	36	3.3	10	71	7.9	35	61	3.6	12	9	1.5	4
Aug.	118	2.4	9	9	1.5	3	44	2.6	9	35	2.9	7	30	2.0	7
Sep.	372	2.8	23	49	2.6	12	102	3.0	23	93	3.0	18	128	2.6	23
Summer	667	2.9	35	94	2.6	12	217	3.6	35	189	3.2	18	168	2.4	23
Oct.	951	5.4	41	162	4.8	31	273	5.6	33	308	6.4	41	233	5.2	20
Nov.	1207	7.4	70	271	6.5	52	555	9.4	70	136	4.4	18	245	7.9	26
Dec.	1063	5.8	24	539	7.3	40	241	6.2	32	98	3.3	10	185	4.6	24
Fall	3221	6.2	70	947	6.3	52	1069	7.3	70	542	5.0	41	663	5.7	26
Total/Mean	6703	4.5	70	1725	4.8	52	2209	4.9	70	1463	4.8	67	1306	3.5	30

TABLE 2—Number of individuals and mean and maximum numbers in a group for Wapiti aggregations defined by sex of animal. In male and antlerless groups the minimum number in a group was 1

		Males			Antlerless			Mixed-sex		
		Total	Group		Total	Group		Total	Group	
Year	Season	indiv.	Mean	Max.	indiv.	Mean	Max.	indiv.	Mean	Range
1971	Winter	110	3.4	26	184	3.2	17	57	8.1	2–23
	Spring	12	1.3	4	63	2.5	14	23	7.7	5–13
	Summer	16	1.5	3	24	1.7	6	47	5.9	2–12
	Fall	93	2.7	13	282	3.9	27	74	12.3	2–52
Annual total		228	2.6	26	558	3.3	27	202	8.4	2–52
1972	Winter	234	3.9	37	243	2.9	30	67	6.1	2–18
	Spring	9	1.1	2	137	3.1	17	23	7.7	5–12
	Summer	32	1.9	4	94	3.0	35	59	8.4	4–24
	Fall	87	4.4	35	313	4.5	32	321	15.3	2–70
Annual total		370	3.5	37	787	3.5	35	476	11.3	2–70
1973	Winter	125	6.9	29	127	4.0	21	37	18.5	4–33
	Spring	31	2.6	3	160	4.4	67	13	6.5	6–07
	Summer	46	2.9	3	109	3.0	10	28	7.0	2–18
	Fall	98	2.7	9	106	2.9	7	251	9.7	2–24
Annual total		300	3.7	29	489	3.6	67	336	9.9	2–33
1974	Winter	25	2.0	10	141	2.7	30	32	8.0	3–21
	Spring	18	1.5	4	123	2.3	15	26	3.3	2–07
	Summer	28	1.0	2	49	2.0	6	41	8.2	2–23
	Fall	59	2.6	12	205	3.9	20	178	9.9	3–24
Annual total		180	1.8	12	482	2.7	30	297	8.2	2–24
Total/Mean		1078	2.9		2316	3.3		1291	9.6	

numerically divergent from other annual means, analysis of variance indicated the difference was not significant ($P > 0.05$). The 4-yr mean group size was 4.5 animals.

During winter, mean group size ranged from 2.6 to 6.1 animals (Table 1). Analysis of variance indicated significant differences among means, and Tukey tests identified the mean of 6.1 for winter 1973 as significantly higher ($P < 0.01$) than all other winter means. Similar analysis indicated no significant differences within the spring, summer, or fall categories.

Comparison of group means among the seasons within the same year revealed that the larger fall groups are most anomalous. Mean group size during fall 1971 was significantly greater ($P < 0.05$) than the mean for summer 1971, and the means for fall 1972 and 1974 were significantly higher ($P < 0.01$) than all other seasons of the same years. The 4-yr mean of 6.2 animals in fall aggregations was significantly larger ($P < 0.01$) than all other total seasonal means (Table 1).

The number of reported groups varied considerably from month to month (Table 1) because of differences in observability. Generally, sightings were less frequent during summer when both dense foliage and increased human presence (tourists) made Wapiti more difficult to observe.

Aggregations were smallest during warm months, increased during the rut (October), and reached maximum size following the breeding season (November). Monthly means for all years range from 2.4 (August) to 7.4 (November) animals per group. There are no significant variations among these means ($P > 0.05$) suggesting the wide range in group size noted for all months (Table 1). The November 1972 mean of 9.4 animals per group was significantly higher than the means for May and August of the same year ($P < 0.05$). No other statistically significant variations occurred among months within annual categories.

Comparison of means by month revealed no statistically significant variations ($P > 0.05$) during January, April, May, July, August, September, October, November, and December. The February 1973 mean of 7.2 animals per group was greater than the 1974 mean of 1.8 animals for the same month ($P < 0.05$), and the March means for the same two years were significantly different ($P < 0.01$). The June 1972 mean of 5.0 was greater than the means for June 1973 and 1974 ($P < 0.05$). It should be noted that the mean values for November and December 1973 were numerically but not significantly lower ($P > 0.05$) than means for these months in all other years.

TABLE 3—Characteristics of Wapiti aggregations observed during aerial surveys 1974–1975. In all male and antlerless groups the minimum number in a group was 1

		All			Males			Antlerless			Mixed-sex		
		Total	Group		Total	Group		Total	Group		Total	Group	
Survey	Year	indiv.	Mean	Max.	indiv.	Mean	Max.	indiv.	Mean	Max.	indiv.	Mean	Range
Feb.	1974	345	1.8	12	145	1.5	6	195	2.1	12	5	5.0	—
Dec.	1974	565	3.6	66	127	1.7	8	377	4.6	66	61	20.3	3–38
Jan.	1975	624	2.8	35	187	1.7	9	424	3.9	35	13	4.3	2–08

Annual and Seasonal Variations in Wapiti Groups Defined by Sex Associations

A wide range in the number of animals per group was evident in all sex-defined Wapiti associations (Table 2). Maximum group sizes exceeded 35 animals for all categories, with 70 Wapiti constituting the largest single aggregation recorded. Mean group sizes, however, ranged only between 2 and 4 animals for sex-separated categories, and between 8 and 12 animals for mixed-sex groups, indicating a preponderance of small bands or single animal sightings. Analysis of variance indicated no significant differences ($P > 0.05$) among either the various categories in the same year or the same category over all years.

Male Wapiti were much more gregarious during late fall and winter than in spring and summer (Table 2). Fall and winter groups of males often included 10 or more individuals, but all large fall aggregations of males occurred during late November and December after breeding ceased. During spring and summer, male groups never exceeded four animals. Among male groups, the mean group size for fall 1974 was larger than those of both spring and fall 1973 ($P < 0.05$). Mean group size for winter 1973 was larger than those of both spring and fall 1973 ($P < 0.05$), and the mean for all winters combined is significantly larger ($P < 0.05$) than all springs combined and all summers combined. Analysis by season indicated the winter mean group size of 1973 to be higher than that of 1974 ($P < 0.01$), and the summer mean group size of 1973 to be higher than that for summer 1974 ($P < 0.05$).

Associations of antlerless Wapiti were common and differed in size in all seasons (Table 2). Large groups (> 20 animals) were most common in fall after the breeding season, and small bands of fewer than five animals were most frequently recorded in summer. Observed variations, however, did not result in statistically significant differences ($P > 0.05$) in mean aggregation size either among seasons or years for the antlerless category.

Mixed-sex groups were recorded for all seasons but were common only during fall rut and post-rut periods (Table 2). Mean group sizes were noticeably larger in mixed associations than in sex-separated categories in all seasons, with post-rut aggregations containing both adult males and females being the largest groups encountered. Because of the low number of sightings in many seasons, analysis of variance was deemed inappropriate for mixed-sex associations.

Aggregation Data from Aerial Surveys

Data for February 1974 included a high percentage of single antlerless and male sightings (combined, 62% of groups) resulting in low mean group sizes for both sex-separated categories (Table 3). The mean of 1.8 animals for all groups was less than half the mean in February in the 1971–1974 period, but corresponded to the lower mean February value for 1974 (Table 1). Winter weather in 1973–1974 began early (late October) and was characterized by thick snow cover and prolonged cold temperatures.

Winter weather the following year (1974–1975) began in mid-December and was not severe. Aerial surveys in December 1974 and January 1975 were conducted at a 6-wk interval and group sizes did not vary greatly between the two surveys (Table 3). Mean sizes of antlerless aggregations were noticeably larger in the latter two surveys. The only difference noted between December 1974 and January 1975 was the presence of larger mixed herds in December, although only three groups were represented in each survey.

Discussion

The wide range of group sizes indicated for most grouping categories and time periods indicates considerable variation under a variety of environmental conditions and during all life phases. The consistency of seasonal patterns in aggregation behavior suggests that sex of the animal, breeding, calving, and rearing of young may be the most important factors determining group size. Sex separation of Wapiti was common in all herds during most of the year and, although mixed groups were recorded for every season in Riding Mountain (Table 2), the number of mixed groups was important only during and following the rut (fall

season). Moran (1973) reported that mixing of the Michigan herd occurred extensively in spring, but this was not common to most other herds and did not occur consistently at Riding Mountain (Table 2) (Murie 1951; Altmann 1952, 1956; Knight 1970).

Groups of males reported by Knight (1970) were generally small but tended to be largest during May and December migrations and smallest during rut. In Riding Mountain, bull groups increased steadily in size from a September low to a January high, with groups as large as 35 animals reported during late fall and winter (Table 2). Adult male groups of this size appear to be unusual and are seldom recorded in other areas. The absence of large male groups in the park in spring may reflect a scattering rather than migration during this season. The fact that male groups showed the greatest number of statistically significant seasonal variations among the sex-defined categories indicates that grouping behavior in males may be more easily and consistently affected by either or both extrinsic and intrinsic factors.

Antlerless groups in the Riding Mountain herd did not show seasonal variations as marked as in some other populations, but the pattern of aggregation appeared typical. Largest groups generally occurred in fall and winter, a decrease was evident in spring, and summer aggregations were smallest (Table 2). Knight (1970) reported an almost identical pattern for female-young bands in Montana, and Martinka (1969) and Altmann (1952, 1956) reported similar trends with the exception of larger post-parturition or "nursery bands" in summer. There was a lack of significant variation in mean group size either annually or seasonally for antlerless groups in Riding Mountain.

The fall-winter of 1972–1973 arrived late and was characterized by a lack of snow and prolonged cold periods, whereas the fall-winter of 1973–1974 arrived early, and had both prolonged cold and thick snow-cover accumulation. Assuming the winter to be the most stressful season for Wapiti, contrasting the two seasons mentioned above revealed the greatest variations in aggregation behavior observed. The mean for all groups for winter 1973 was significantly higher than means for all other winters (Table 1). The monthly means for all groups in February and March 1973 were significantly greater than the means for the same months in 1974 (Table 1). Although not significantly different, the mean group sizes for all Wapiti in November and December 1973 were lower than similar categories of means for these months in all other years.

Therefore, it appears that the large mixed and antlerless herds typical of fall and winter periods are larger and remain together longer during a mild winter, and are both smaller and more easily scattered during severe winters. Statistically, male groups were most influential in the observed variations, but all sex-defined groups were noticeably smaller during fall 1973 and winter 1974 (Table 2). I believe that this results from an early onset of winter conditions that interferes with the freedom of movement of small groups following the rut, and precludes their normal coalescence into larger post-rut aggregations. Both Troyer (1960) and Knight (1970) suggested that thick snow cover tends to break Wapiti populations into smaller groups.

Analysis of vegetation and consequent variations in food supply are only indirectly assessible from the data. The noted changes in estimated Wapiti populations (Rounds 1977) coupled with consistent annual grouping behavior during the 4 yr of record (Table 1), suggest that annual variations in food (either quantity or quality) did not affect aggregation. Because food availability would in part be a function of animal density, the population variations without concomitant behavior change indicate either that changes in vegetation are a minor factor in determining grouping of animals or changes in food supply did not vary greatly during the 4 yr.

Behavioral reactions of Wapiti to predation have not been studied in Riding Mountain and inferences cannot be drawn from existing data. A sizable Gray Wolf (*Canis lupus*) population exists within the park and evidence of Wapiti kills by wolves is common. I do not believe, however, that predation has a prolonged effect on mean group size because of the constant mobility and short-chase habits of Gray Wolves, the presence and effect of alternate prey (Carbyn 1974), and the large number of Wapiti aggregations that would have to be encountered and scattered to affect grouping data.

Wapiti populations in the western areas of North America characteristically avoid seasonal extremes by vertical migration. The maximum relief of 600 m in Riding Mountain National Park has little effect on the seasonality of the Canadian prairies, and, although seasonal shifts in distribution are evident, the Wapiti must tolérate extreme climatic variations. Physiography and migration, therefore, are not nearly as important in determining aggregations in flat-land populations as they are in mountainous Wapiti populations (Moran 1973). In total, antlerless Wapiti in Riding Mountain have typical season grouping behavior, although seasonal changes are not as marked as those in herds in mountainous terrain. The greater number of large groups of males during late fall and winter, and the lack of larger groups of all sex and age categories in spring, may be responses to the site and situation factors operative in Riding Mountain National Park.

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Breeding Biology of Orchard Orioles in a New Population in Manitoba

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The Orchard Oriole (*Icterus spurius*) was first recorded possibly breeding on the Delta Beach Ridge, Manitoba, in 1975, and from 1976 to 1978 a small population produced young each year. Adult and yearling males arrived at the same time in spring. Both age classes of males nested equally successfully, and both returned to nest in a later year. No females, nor young reared on the study area, are known to have returned. The family units stayed together until departure in late summer. Division of labor by parents feeding young apparently occurred. Adults did not molt on the breeding ground prior to migrating in fall.

Key Words: Orchard Oriole, *Icterus spurius*, breeding biology, range expansion, founders, Manitoba, subpopulations.

The AOU Check-list (1957, p. 530) and Godfrey (1966, p. 356) include central southern Manitoba in the breeding range of the Orchard Oriole (*Icterus spurius*). This was actually based on only a few sight records, with nestings in 1923 and 1929. This species, however, now regularly breeds in southern Manitoba (see also Knapton 1979). In 1975–76, it colonized the Delta Beach Ridge (50°11′N, 98°19′W), where I have been studying passerine breeding biology and habitat use since 1973. Breeding behavior and success data for the first pairs nesting there add to the scanty knowledge of the breeding biology of this species, primarily from Arkansas (Thomas 1946), Florida (Grimes 1931), Louisiana (Dennis 1948), and Wisconsin (Smith 1947).

The first Orchard Oriole recorded in Manitoba was an unsexed individual seen at East Bay in 1921 (Hatch 1965). Between 1923 and 1927, several adult males and at least two unsexed birds were seen (Lawrence 1928). A nesting was reported at Thornhill in 1923 and five nests were found in 1929 at Cypress River (Cartwright 1931). The first specimen (Manitoba Museum of Man and Nature Number 2043), an adult male, was found in Winnipeg on 30 May 1929. A second adult male was taken at Lake St. Martin on 6 June 1932 (Shortt and Waller 1937). The species was not recorded again in Manitoba until 1960. Since then it has been seen in increasing numbers in southern Manitoba (Hatch 1965; Gardner 1971; Knapton 1979) and in Saskatchewan (Callin 1975).

The first record of the Orchard Oriole on the Delta Beach Ridge was a subadult male observed on 12 June 1971 by John L. Harcus (personal communication 1978). This was his only sighting of this species during studies in 1968–1971. My first record there was a flying juvenile mist-netted on 3 August 1975. During 1976–1978 a small population nested on this study area and provided the information upon which this report is based.

Study Area

The study area (Figures 1 and 2), where most of the Orchard Orioles studied nested, is a 2000-m portion of the Delta Beach Ridge immediately west of the Assiniboine River Diversion. This narrow strip of deciduous trees on a dune ridge that separates Lake Manitoba and the Delta Marsh (see MacKenzie 1979 for a detailed description) includes Sand-bar Willow (*Salix interior*), Peach-leaved Willow (*S. amygdaloides*),

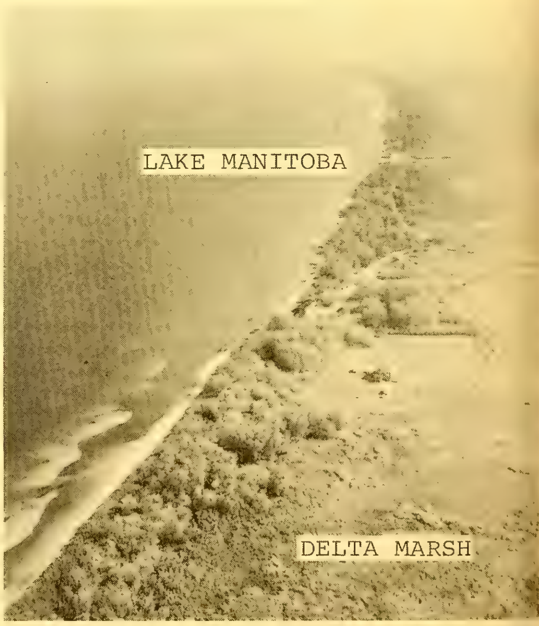

FIGURE 1. A portion of the Delta Beach Ridge, Manitoba, showing the relationship between Lake Manitoba and the Delta Marsh.

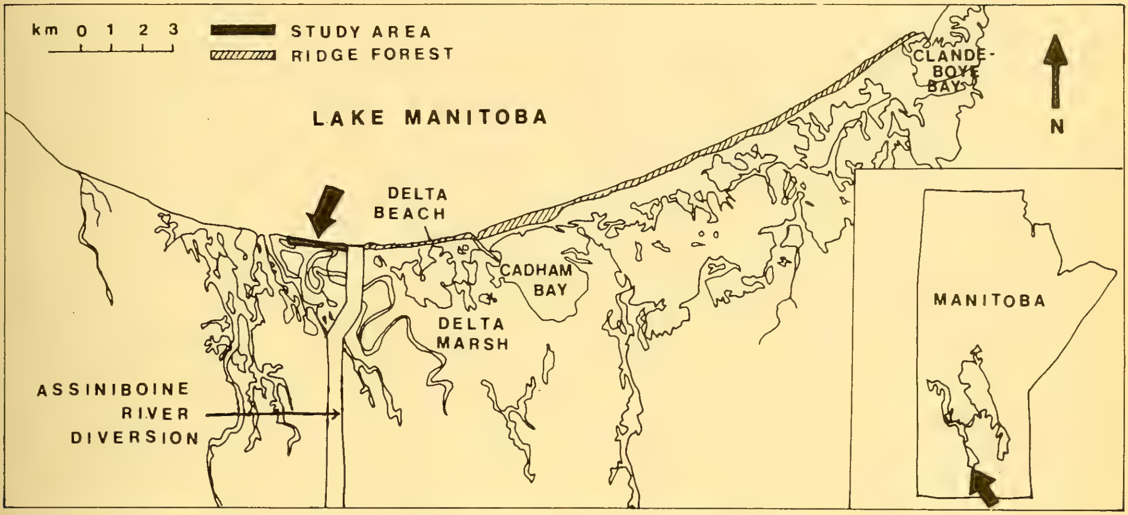

FIGURE 2. Study area portion (indicated by arrow) of the Delta Beach Ridge, Manitoba.

Manitoba Maple (*Acer negundo*), Eastern Cottonwood (*Populus deltoides*), Green Ash (*Fraxinus pensylvanica*), Red-berried Elder (*Sambucus pubens*), cherry (*Prunus* sp.), and Red-osier Dogwood (*Cornus stolonifera*).

Results

Ages of Founders

Male Orchard Orioles of different age classes are readily distinguished (see Godfrey 1966). Breeding females cannot be aged. All groups are similar in weight and size (Table 1). Of 40 aged males seen in Manitoba between 1960 and 1974, 22 (55%) were adult-plumaged (ASY) and 18 (45%) were yearling (SY) birds; 10 females and 1 juvenile were also seen. The two males in Saskatchewan, one of them nesting, were SY birds. R. W. Knapton (personal communication 1978) noted that seven of nine nests in Lyleton, Manitoba, in 1974–1976, were tended by ASY males; the other males were not seen. Although up to three SY males were present in Lyleton each year, none was seen tending a nest (see also Knapton 1979).

On my study area in 1976, two nests were tended by ASY males, one by an SY male, and the fourth nest was deserted before the male could be observed. At least two other SY males were seen. In 1977, three nests were tended by ASY males and three by SY males, and two other SY males were seen on the ridge east of the study area. All four nests located in 1978 were tended by marked ASY males that had nested successfully on the study area the year before, two as ASY males and two as SY males. Two nests found on the ridge east of the study area in 1978 were tended by ASY males, and up to five additional ASY males were also seen there. At least one, and possibly three SY males were on the study area after mid-June.

Two females were banded in 1976, six were banded and color-marked in 1977, and two in 1978. None of these females from 1976 and 1977 returned in 1978. No banded young (n = 13) have returned.

TABLE 1—Body weights and measurements (± SE) of mist-netted Orchard Orioles, Delta Beach Ridge, Manitoba, 1976–1978

	Body weight (n)[1]	Exposed culmen (n)	Flattened wing (n)[2]	Tail (n)[2]
ASY Males	20.5 (6)	14.7 ± 0.2 (4)	79.3 ± 0.6 (4)	69.0 ± 1.0 (3)
SY males	22.5 (5)	15.5 ± 0.2 (6)	77.8 ± 0.4 (6)	64.0 ± 2.1 (5)
Females	20.9 (15)	14.7 ± 0.2 (9)	74.2 ± 0.6 (9)	64.4 ± 0.8 (8)
Juveniles (flying)	21.0 (13)	—	—	—

[1]Includes mist-net recaptures; weights similar to the small sample in Graber and Graber (1954).
[2]Wing measurements fall within the ranges given by Graber and Graber (1954) and Dickerman and Warner (1962); tail measurements are slightly smaller.

Spring Arrivals

In 1976, one ASY male was seen on the study area on 22 May and an SY male on 24 May. Another ASY male was present on 28 May. The first female was seen on 3 June, and by 6 June three had been mist-netted and banded. In 1977, at least six males (including three SY) were present by 28 May. The first one, an ASY male, was seen on 25 May. By 5 June five females had been netted and color-marked. In 1978, the first (color-marked) male was seen on 16 May, about 200 m west of where it had nested in 1977 as an SY male. The first female was seen, with the first ASY male, on 24 May. No SY males were seen until late June.

Nest Sites and Breeding

The mean distance between Orchard Oriole nests on the study area, not including renests, was 128 m in 1976 (n = 4, range 95–170 m), 188 m in 1977 (n = 6, range 120–330 m), and 440 m in 1978 (n = 4, range 200–610 m). The 17 nests, including three renests, were in Manitoba Maple (n = 7), Green Ash (n = 5), Eastern Cottonwood (n = 4), and Sand-bar Willow (n = 1). The mean (± SE) nest height was 8.8 ± 0.8 m, in trees that averaged 11.7 ± 1.1 m in height.

Nests were not visited frequently, but observations of adult behavior were helpful in outlining the phenology of breeding. All first nests were completed by 5–7 June, and the young had fledged by 7–10 July. Nest construction and clutch initiation occurred at about the same time in pairs with an SY male and with an ASY male. No second broods were reared or attempted by any of the successful pairs.

Nest success was determined by observing the adults and the newly fledged young when they began to move away from the nest sites. Of the 14 first nests in 1976–1978, 10 were successful and 4 were unsuccessful. Renesting occurred three times. In 1977, the (successful) replacement nest was within 10 m of the first nest in the same tree species (*Populus*). In 1978, one (successful) renest, in *Fraxinus*, was 520 m east of the original nest, in *Acer*. A second 1978 nest in *Acer*, deserted following Brown-headed Cowbird (*Molothrus ater*) parasitism, was replaced 360 m west in *S. interior*, but eventually failed.

One nest out of six whose contents were examined was parasitized by a cowbird. The cowbird egg was laid when the oriole clutch contained two eggs; one oriole egg was removed by the cowbird; the nest was deserted 2 d later.

The mean clutch size in five unparasitized nests was 3.6 eggs (3 of 3 eggs, 1 of 4, 1 of 5). One clutch of three eggs was a renest. Clutch size for the Orchard Oriole is given by various authors as four to six, or generally five (Dennis 1948; Bent 1958).

Mating System and Parental Care

Season-long monogamy (see Selander 1972, p. 193) prevailed in all 10 territories where the nests were successful. The family groups later moved off the territories, but remained together until fall migration. A 1977 renest involved a marked pair whose first nest had failed. In 1976, one male disappeared soon after the nest was completed, followed shortly by the female.

The general course of development in the nests was similar to that described by Thomas (1946) and Bent (1958). The young fledged at about 2 wk of age, and spent about 1 wk in dense cover within 20–30 m of the nest. The family units (male and female + brood) then moved away from the vicinities of their nests.

Adult Orchard Orioles appeared to divide up their fledged broods (see also Smith 1947), much as Smith (1978) described for Song Sparrows (*Melospiza melodia*). Five family groups in 1976–1978 were watched for short periods almost daily. In three broods of three, two (unmarked) young invariably followed the female and were fed by her, while one (unmarked) young followed the ASY male and was fed by him. In one brood of four, three young were usually seen with the ASY male and one with the female, although often the entire brood was also seen together. Another brood of three was always seen together, although the unmarked young may have been fed selectively by the SY male and female.

Prebasic Molt

Adult Orchard Orioles do not molt on the breeding areas prior to migrating in the fall (see also Hamilton and Barth 1962). A female mist-netted on 20 July 1976 and ASY males netted on 26 and 30 July 1977 were not molting and were still in the alternate plumage. Adults observed up to 24 August 1978, through a 40× spotting scope as they tended broods, showed no molting of remiges. This contrasts with the Northern Oriole (*I. galbula galbula*) (Sealy 1979), which nests abundantly on the study area; it molts before migrating in the fall.

Discussion

The expansion of the Orchard Oriole's breeding range in southern Manitoba appears to have been accomplished by small groups of individuals pioneering suitable areas. Here the species is probably subject to fluctuations both in actual numbers and in the limit of its breeding range, as is suggested by the absence of records between 1932 and 1960. Immediately south, the Orchard Oriole is fairly common in southern North Dakota but is an uncommon and local breeder in the north (Stewart 1975). It does not breed in the northwestern part of Minnesota (Green and Janssen 1975), so it is likely that the pioneering individuals moved northward into Manitoba from North Dakota.

The initial invasion of an area generally involves low numbers of individuals, many of which are juveniles (Lack 1954; Root 1962; Austin 1971). Only slightly more males in the small founder population I studied were ASY males. SY males nested as successfully as ASY males in the present study. Individuals of both age groups returned in 1978 after nesting there sucessfully in 1977, suggesting the rapid development of site tenacity in males of this founder population. I found only one other reference to nesting by SY males of this species (Thomas 1946, p. 163). Some observers, however, may not have distinguished SY males from females tending nests. Thirty-five percent of the 36 males banded as ASY birds by Thomas (1946) returned in later years to her study area in Arkansas. None of the 14 SY males she banded returned or were trapped, but a few males banded as juveniles did return and nested, in one case for 3 yr. Thomas concluded that males do not return to where they nested as SY individuals but rather seek a new area where they may return year after year.

Hamilton (1961) proposed that, in migratory North American orioles, the adult males being more brightly colored than the females facilitates the rapid establishment of territories and pair bonds by reducing agonistic encounters between the sexes (see also Hamilton and Barth 1962; Lowther 1975; Bailey 1978). Hamilton believed that the ASY males arrive on their breeding grounds first in spring and establish territories by the time the females arrive a week or so later, when pairing occurs apace. This pattern also emerged from the present study, except that ASY and SY males arrived essentially at the same time. Some of each were seen with females within one week. The successful nesting of SY males supports Rising's (1970) suggestion that visual recognition, although possibly important, is not the key factor for sex recognition and pair formation in at least temperate-nesting orioles. Recognition of and response to male song might be more crucial to pair formation. This aspect requires study.

Ficken (1963) observed ASY male American Redstarts (*Setophaga ruticilla*) acting as aggressively toward SY males (which have a female-like plumage but sing territorially) as toward adult-plumaged males. She also noted that ASY males react very aggressively toward females early in the breeding season, which again illustrates that a female-like plumage may elicit aggression (but see Rohwer 1978). Fights between SY and ASY Orchard Oriole males have been observed elsewhere, although the species is in general non-territorial (Dennis 1948). No such encounters were seen in the present study. The widely spaced nests (see also Schaefer 1974) on my study area contrast with the colonial nesting situations often found in this species (Kopman 1915; Thomas 1946; Dennis 1948), where inter-male aggression might be expected to occur more frequently (see also Ficken and Ficken 1967).

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Winter Habitat Use by White-tailed Ptarmigan in Southwestern Alberta

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Winter habitat and movement of White-tailed Ptarmigan (*Lagopus leucurus*) were investigated in Alberta during January and February of 1977 and 1978. The critical feature influencing habitat use appeared to be the availability of food, mainly willow (*Salix* spp.). In 1977, most sightings of ptarmigan occurred in alpine cirques where low-growing willows remained snow-free. Alpine willows were completely snow-covered in 1978, when 99% of ptarmigan sightings occurred along stream courses and willow flats in subalpine forest, 2.5–7.5 km from cirque habitats. Food availability, determined by snow accumulation, may be an important factor influencing the migration of ptarmigan.

Key Words: White-tailed Ptarmigan, *Lagopus leucurus*, winter habitat, migration, Alberta, activity patterns, food availability, *Salix*.

Most information on the winter ecology of White-tailed Ptarmigan (*Lagopus leucurus*) is from Colorado, which lies near the southern limit of the species' distribution (Braun and Schmidt 1971; Hoffman and Braun 1975, 1977; Braun et al. 1976). In that area, willows comprised 89% of the winter diet of both sexes (May and Braun 1972). Males usually remained close to breeding areas and wintered at or near treeline where willows were kept snow-free by wind action. Females wintered in the tall, dense willow-dominated communities of large drainage basins and along stream courses at lower elevations (Braun et al. 1976). Thus partial segregation of the sexes occurred spatially as a result of habitat selection.

Differences in summer habitat use exist between ptarmigan populations in Colorado and Alberta (Herzog 1977). Therefore, this investigation was undertaken to test the applicability of the Colorado findings to wintering populations of White-tailed Ptarmigan in southwestern Alberta.

Study Area and Methods

Fieldwork was conducted periodically during January and February of 1977 and 1978, 9–10 km E of the Kananaskis Lakes, Alberta. The area included the alpine basins described by Herzog (1977), the headwaters of the Elbow and Sheep rivers and the upper drainages of Burns, Pocattera, Rae, and Storm creeks. The difficulty of access to and within the study area prevented searches of the entire region but the major areas of ptarmigan use were identified. Birds were observed in four general habitat types within these areas: (1) alpine cirque (2400–2600 m elevation) — open tundra with scattered clumps of willow 5–30 cm in height, (2) treeline krummholz (2300–2500 m) — widely spaced dwarf conifers, primarily Alpine Fir (*Abies lasiocarpa*), Englemann Spruce (*Picea engelmannii*), and Whitebark Pine (*Pinus albicaulis*), with occasional patches of willow up to 50 cm in height, (3) subalpine forest (2000–2400 m) — open forest of spruce, fir, and Alpine Larch (*Larix lyallii*), with scattered clumps of willows, birch (*Betula glandulosa*), and juniper (*Juniperus communis*), and (4) stream course (1900–2100 m) — drainage ways through subalpine forest dominated by willows 2–3 m in height at lower elevations.

Ptarmigan were located by initially searching the high alpine basins and then proceeding downslope through forested habitats and along stream courses. A pointing dog was occasionally used to aid in locating birds. The presence of ptarmigan was also shown by tracks and snow roosts. Distances of movements to winter sites were estimated from straight-line distances between ptarmigan sightings and breeding areas and by observation of marked individuals. The age of ptarmigan captured in winter was determined by pigmentation of outer primary feathers but no reliable method was available for determination of sex (Braun and Rogers 1971). Sex was known for birds marked in the summer of 1976 (unpublished data) and relocated in winter.

Weather data and snow depths for Highwood Summit were obtained through Alberta Forest Service, Alberta Environment, and Water Survey of Canada.

Results and Discussion

Ptarmigan were encountered on 30 occasions during the two winters. In 1977, 88 birds were observed as 16 flocks (group of two or more birds) and two single birds (Table 1). Eighty-five birds were located in 1978: 11 flocks and a single bird (Table 1). Few ptarmigan

TABLE 1—Habitat use by White-tailed Ptarmigan, and mean distance ± SD (km) of flocks during January and February of 1977–1978 from nearest known breeding areas

Habitat type	No. of birds (flocks)		Mean distance (km)	
	1977	1978	1977	1978
Alpine cirque	58 (10)	—	0	—
Treeline krummholz	9 (2)	1 (—)	1.5 ± 0.8	—
Subalpine forest	6 (2)	56 (6)	5.2 ± 0.1	5.5 ± 1.8
Stream course	15 (2)	28 (5)	1.2 ± 0.4	3.2 ± 0.3

were observed more than once, based on observations of marked birds and locations of individual flocks. Average flock size for the two winters was six birds (range 2–20).

Most ptarmigan in 1977 were observed in alpine cirques (Table 1), areas typically used in spring and summer (Herzog 1977). Some marked individuals (seven males, three females) had not migrated from their breeding areas. Few ptarmigan were detected downslope of cirques in the subalpine and stream course habitats (Table 1). The general lack of ptarmigan sign (tracks and snow roosts) below alpine areas also indicated that most birds probably remained at higher elevations. In contrast, ptarmigan were not observed during any searches of cirque habitat in 1978; virtually all sightings occurred in the subalpine and stream course habitats (Table 1). Habitat use was different between the years (chi-square test, $P < 0.01$).

The distances from the treeline krummholz and subalpine forest habitats used by ptarmigan to the nearest breeding areas were similar both years (Table 1). Birds were sighted at the same general locations within these habitats each year, indicating the suitability of these areas during both winters. Ptarmigan wintered along the same stream courses each year but were at lower elevations in 1978 (Table 1).

Ptarmigan distribution was mainly affected by the availability of food resources, primarily willow. In 1977, willows remained exposed above the snow in cirque habitats (Figure 1), and birds were frequently observed feeding at these sites; willows in cirque habitats were completely covered with up to 1.2 m of snow throughout the winter study in 1978. Because this was the only source of food in this habitat, ptarmigan moved to lower elevations where food was available. Ptarmigan also may exhaust local food resources and migrate before all willows are completely snow-covered; in 1977, willows protruding 5–15 cm above the snow at one alpine cirque vacated by ptarmigan had virtually every bud and twig tip browsed. Such extensive browsing might lead to twig desiccation and ultimately reduce the amount of food available to ptarmigan the following spring.

The availability of low-growing willows depends on the amount of snowfall (Braun and Schmidt 1971). From 1 November 1976 to 1 March 1977, snowfall equivalent to only 14 cm of precipitation was recorded at Highwood Summit, compared to 23 cm in 1977–1978, and a mean of 28 cm for 1963–1976. The actual depth of snow on 3 January 1977 was only 36 cm, the lowest on record for a 7-yr period (mean of 140 cm; no data 1978). On 27 April, snow depth in

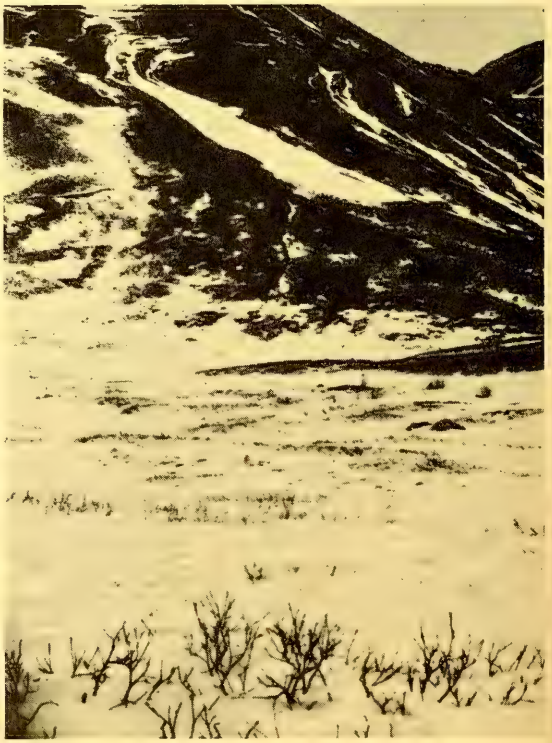

FIGURE 1. Exposed willows in alpine cirque habitat on 5 February 1977; the availability of this food resource allowed ptarmigan to remain in breeding habitat throughout that winter.

1977 was again 36 cm compared to 113 cm in 1978 (mean of 165 cm 1963–1976). Because snowfall throughout March and April of 1977 remained well below normal, some ptarmigan probably remained in breeding habitat throughout the winter.

Migration of other species of grouse also varies with the availability of winter foods. Willow Ptarmigan (*Lagopus lagopus*) migrated in Norway (Myrberget 1975) and Alaska (Weeden 1964; Irving et al. 1967), but remained in areas of snow-free shrubs on the breeding range in Newfoundland (Bergerud 1970). Dalke et al. (1963) reported that winter migration of Sage Grouse (*Centrocercus urophasianus*) in Idaho appeared dependent on snow depths, but Eng and Schladweiler (1972) and Wallestad (1975) indicated that Sage Grouse in central Montana were usually non-migratory. Some Rock Ptarmigan (*Lagopus mutus*) of central Alaska lived in breeding habitat all winter, but most birds migrated (Weeden 1964). Weeden suggested that such movements were necessary because of food shortage in winter in breeding habitats. Results from my study support this hypothesis, and I suggest that the geographic differences in migration of Willow and Sage Grouse may be due to variations in snow accumulation between different areas. But as some Rock Ptarmigan depart before snow cover develops (R. B. Weeden, personal communication), food shortages may be an ultimate rather than a proximate factor for migration of some segments of grouse populations.

Habitat use by the sexes of White-tailed Ptarmigan was generally similar in Alberta to that reported in Colorado (Braun et al. 1976). Twenty-three marked ptarmigan were identified at or above treeline (cirque and krummholz types): 11 adult males, 9 subadult males, and 3 adult females. Below treeline (subalpine and stream course habitat), seven ptarmigan were identified; five adult females, one subadult female, and one subadult male. Only limited data were collected, as ptarmigan were difficult to approach closely and leg-bands were hard to identify on the feathered tarsi of the birds.

This difference in habitat use was also reflected in the distances travelled during migration. Excluding observations of birds that did not migrate in 1977, adult females migrated the longest distances ($\bar{x} \pm$ SD = 6.4 ± 1.2 km N = 5) followed by a subadult female (6.0 km N = 1), subadult males ($\bar{x}$ = 3.8 ± 1.7 km N = 2) and adult males ($\bar{x}$ = 1.5 ± 0.7 km N = 4). Although the number of marked birds involved in these movements was small, the results for each sex and age class are nearly identical to the average distances of autumn migration recorded by Hoffman and Braun (1975). Weeden (1964) reported similar segregation of sexes by habitat and distance among Willow and Rock Ptarmigan in Alaska.

The reason for the sex-segregation of White-tailed Ptarmigan in winter is uncertain. Hoffman and Braun (1977) suggested that males may compete more successfully to territories in spring if they winter close to their breeding areas. Perhaps males defend the limited food resources at higher elevations throughout the winter, thereby causing female birds to travel to other habitats. Another possibility is that the taller willows growing at lower elevations might contain specific nutrients required by females during winter or necessary to increase energy reserves in late winter prior to egg production in spring. If the movements of females are related to dietary requirements rather than only food abundance, the timing of their departure from breeding range may be less dependent on snow conditions than that of males. This hypothesis could be tested by closely monitoring the timing of migration and the use and availability of high-quality winter foods.

Acknowledgments

David Graham, Alberta Environment, Edmonton, kindly provided the weather data. I also thank D. A. Boag, Department of Zoology, University of Alberta, for permission to use the R. B. Miller Biological Station as a field camp. I am very grateful for financial assistance provided through Alberta Department of Recreation, Parks and Wildlife, Fish and Wildlife Division, by W. Wishart, who also offered helpful comments on an earlier draft.

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Isoëtes eatonii, a Quillwort New for Canada

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The discovery of *Isoëtes eatonii* in the Severn River in Ontario extends the range of the species 360 km NW and adds a new species to the flora of Canada.

Key Words: *Isoëtes eatonii*, Eaton's quillwort, Canada, first record, flora, Ontario, range extension.

The discovery of *Isoëtes eatonii*, Eaton's quillwort, in the Severn River, Simcoe County, Ontario adds another species to the Canadian flora. It is a small, perennial, aquatic plant that reproduces by heterospory. The first collection in Ontario was made by R. Bobbette *4158*, on 22 September 1974. The plants were collected under water at a depth of about 0.6 m, and the river bottom varied from coarse sandy gravel to finer peaty clay. The plants were in sparse communities usually without other nearby vegetation, but sometimes intermixed with populations of *Najas* sp. and *Potamogeton spirillus*. At this point the Severn River is dammed (Big Chutes Dam) and is part of a Lake Ontario – Lake Simcoe – Lake Huron canal system (Trent Canal). Therefore the Severn River here is slow-moving and is well travelled by motor boats.

This area was revisited in 1977 and collections of *I. eatonii* were made in nearby locations in somewhat different habitats. On 18 September 1977 L. Kott and E. Kott collected plants from pure sand bottom at a depth of about 1.3 m, with no other plant communities nearby (collection *535*). The plants were well spaced but easily visible in the clear water. Another collection was made from another site in 0.5 m of water, the plants growing in a very dense patch of *Pontederia cordata* (collection *536*). A fourth collection in October 1977 by J. Goltz (collection *557*) was made on the opposite (north) side of the Severn River near Pretty Channel, District of Muskoka, with the plants growing in sand at 0.7 m, and here the species appeared to be locally abundant.

Isoëtes eatonii appears, therefore, to be well represented in this area of the Severn River, because it has been collected in at least four different sites within the same general area. It is not known whether this represents the natural northern limit of the species or whether it was accidentally introduced into the river by the boats from the New England area, where this species is locally more abundant (Figure 1).

This species was first collected by A. A. Eaton in 1895 in Kingston, New Hampshire and described as a new species of quillwort in 1897 by Raynal Dodge. Most of the early collections of this species came from sites in a small area in New Hampshire around Kingston and the northeastern corner of Massachusetts. These occur in several rivers: Powow, Lamprey, and Parker. Other, but much less common, collection sites for *I. eatonii* are from other New England states and the surrounding states of New York, New Jersey, and Pennsylvania (Figure 1). Our Severn River population is about 360 km from the nearest known collection cited at Cayuta Lake in New York State (Clausen and Smith 1939).

The determination was made on morphological character of leaves and spores as compared to the norms for the species and type material (MO 100757). This species is characteristic in that it has, on the average, more leaves per plant than any other species occurring in Canada. From the 105 plants examined, borrowed from Missouri Botanical Garden (MO), New York Botanical Garden (NY), University of Vermont (VT), and Cornell University (CU), the leaf numbers per plant ranged between 12 and 135 but Dodge (1897) and Eaton (1900) report leaf number up to 200. Our plants had leaf number ranging between 12 and 34.

Isoëtes eatonii has the longest leaves in the genus in North America, equalled in size only by *I. engelmanii* from New England. Leaves can be up to 60 cm in length in this species (Eaton 1900) and the leaves in our Severn River plants were between 16 and 24 cm long (range for 105 study plants was 8–60). In this species only, leaf length varies with the depth of the water, producing longer leaves in the spring when the water is deeper, and considerably shorter leaves in the summer when water is shallower. In some cases the plants are emergent on the dry banks in the summer months when water levels have dropped severely. This water-level fluctuation does not occur in the Severn River because of the Big Chutes Dam and therefore our plants probably would not display any difference in leaf length between spring and summer leaves.

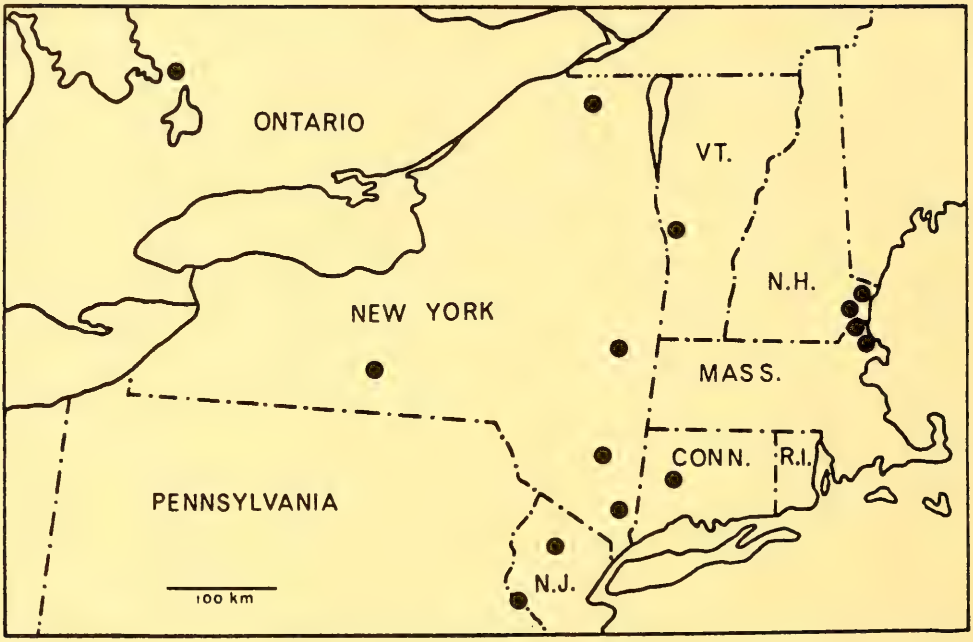

FIGURE 1. Selected locations of *Isoëtes eatonii* showing typical range of distribution for this species (see Appendix for collection data).

Towards the end of the growing season the yellowing leaves become limp and lie flat on the substrate, losing their upright, quillwort appearance. In late fall the leaves break away from the plant easily, differing from some other species in eastern Canada (*I. echinospora* and *I. macrospora*) which tend to have some green leaves that remain with the plant during the winter.

Where leaf morphology can be variously and sometimes very severely affected by environmental factors, such as water depth, or water flow, spore characters are the most reliable features in determining some species of *Isoëtes*.

The sculpture of the megaspore of this species in the original description of Dodge (1897) is given as "labyrinthiform-convolute" and later described by Pfeiffer (1922) as "with irregular commissural ridges and with faces marked very irregularly by crowded short meandriform elevations, sometimes with rounded teeth."

With the aid of the SEM (Scanning Electron Microscope) the megaspores are seen to have an appearance of brain coral, with short ridges and mounds (Figure 2A), all of even height, closely crowded and having a secondary texture of fine spines on these ridges or mounds (Figure 2B). These features compare well with SEM results of type material (Figure 2C) and with other material of *I. eatonii* from the northeastern United States.

The microspore walls appear variable from almost smooth to slightly papillose or even with low widely spaced, thick-based spines (Figure 2D).

In the standard manuals used for species identification (Fernald 1950; Gleason 1968; Wherry 1972) *Isoëtes* spores are always represented by drawings which, at times, are subject to the artists' own interpretations of the spore coat sculpturing, resulting in drawings that are less than accurate. These representative SEM photographs of *I. eatonii*, including that of the type, show the typical character of the spore coat. No other similar photographs as yet have appeared in the literature.

The megaspores of *I. eatonii* are strikingly different from those of any other species of *Isoëtes*, which may have either distinct sharp spines; interrupted, well-spaced, high crests; or anastomosing ridges which, at times, form a network of honeycombs all over the surface of the spore.

The spore sizes for this species are small compared to some other *Isoëtes* species. Pfeiffer (1922) gives 396–520 μm and Dodge (1897), 300–450 μm as ranges for megaspores. Our study revealed a range of 320–534 μm and the Severn River specimens were well within this range at 373–443.

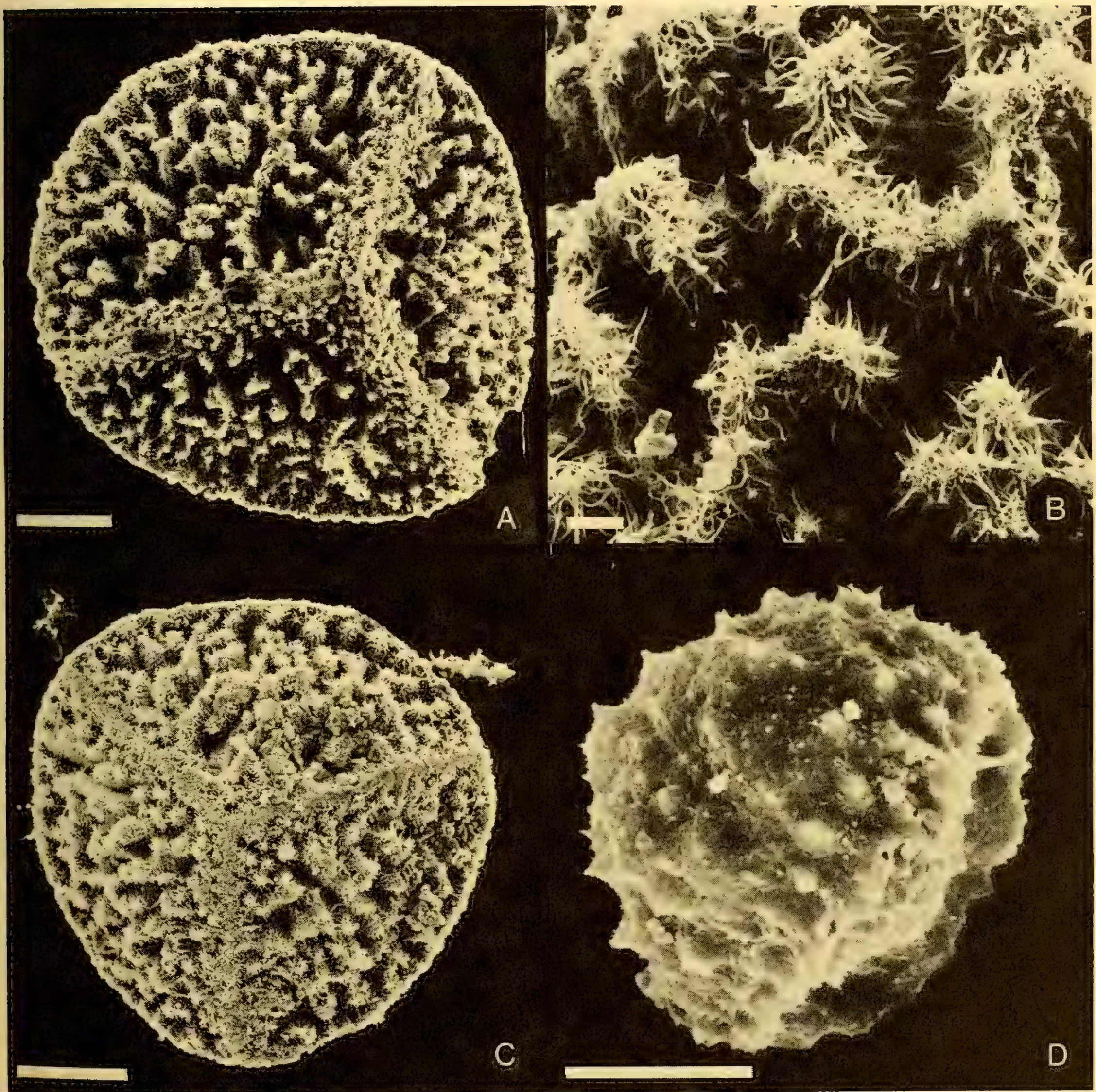

FIGURE 2. Scanning electron micrographs of spores of *Isoëtes eatonii*: A, proximal face of megaspore showing characteristic sculpturing and prominent triradiate ridge (Severn River, *Kott 535*) (bar scale = 100 μm); B, secondary texture of fine spines on the megaspore (bar scale = 10 μm); C, megaspore from type material from Kingston, New Hampshire (bar scale = 100 μm); D, microspore (Severn River, *Kott 535*) (bar scale = 10 μm).

Microspores are also small in comparison to those of other species and range from 23 to 25 μm in the material studied. Previous workers (Dodge 1897; Pfeiffer 1922) give a higher range for microspores at 25–30 μm. Perhaps the discrepancy between the earlier measurements and those in this study can be attributed to the more refined methods of today. Measurements of spores were made by camera lucida drawings or from SEM photographs.

This species, *I. eatonii*, is newly reported here for Canada. It has not appeared in Scoggan's (1978) *Flora of Canada*, nor Boivin's *Enumeration of the Plants of Canada* (1966), nor in Soper and Rao's (1958) article on *Isoëtes* of Eastern Canada. This species has not been included in floras of other regions of Canada, in listings on the provincial or county level. This record is supported by voucher specimens from the Severn River (L. Kott & E. Kott *535* and *536*) made on 18 September 1977 and housed in the University of Guelph herbarium (OAC).

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Appendix

Collection data of some specimens examined represented by dots in Figure 1: CONNECTICUT: Plymouth, September 6, 1903, *C. H. Bissell* (MO 1852220); MASSACHUSETTS: Tuxbury's Pond, Amesbury, September 19, 1898, *A. A. Eaton 919* (MO 100780); Parker River, *Dodge* (MO 100779); NEW HAMPSHIRE: Kingston, 1895 *R. Dodge* (MO 100757) Type; Newmarket, August 19, 1899, *A. A. Eaton 217* (MO 100774); NEW JERSEY: Lake Hopatcong, October 14, 1939, *Jas. L. Edwards* (MO 1570374); NEW YORK: Eddyville, Ulster County, September 5, 1936, *W. C. Muenscher and O. F. Curtis 5396* (CU); ONTARIO: Severn River, Simcoe County, September 22, 1974, *R. Bobbette 4158;* PENNSYLVANIA: Delaware River, Pt. Pleasant, September 4, 1899 (NY); VERMONT: Orwell, August 8, 1915, *Eames 9204* (VT).

Collection data of *I. eatonii* that are represented by dots in Figure 1 taken from Clausen and Smith (1939): NEW YORK: Cayuta Lake, Schuyler County, *W. C. Muenscher 17657;* Lower Chateaugay Lake, Franklin County, *W. C. Muenscher and B. Maguire 666*; West Branch Reservoir, Carmel, *W. C. Muenscher and O.F. Curtis 5397;* Glass Lake, Rensselaer County, *W. C. Muenscher and O. F. Curtis 4128.*

Importance of Arboreality in *Peromyscus leucopus* and *Microtus pennsylvanicus* Interactions

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Newton, Sandra L., Thomas D. Nudds, and John S. Millar, 1980. Importance of arboreality in *Peromyscus leucopus* and *Microtus pennsylvanicus* interactions. Canadian Field-Naturalist 94(2): 167-170.

White-footed Mice (*Peromyscus leucopus*) did not increase arboreal activity in the presence of Meadow Voles (*Microtus pennsylvanicus*). This supported field observations that arboreality is of little significance as a means of habitat partitioning and avoidance of interspecific interference competition in these species. Arboreal separation appears due to innate differences in habitat use by voles and White-footed Mice. *Peromyscus* climbing activity declined with the onset of winter regardless of the presence of *Microtus*.

Key Words: aboreal activity, interspecific competition, *Microtus pennsylvanicus, Peromyscus leucopus.*

The ubiquitous North American genus *Peromyscus* has been extensively studied with respect to both congeneric (e.g., Smartt 1978) and confamilial (e.g., Grant 1972) interspecific competition. Within the genus, morphology of the feet and tail varies with arboreality (Horner 1954; King 1968) and it has been suggested that differential arboreal habitat use may facilitate coexistence among microsympatric congeners (Evans 1957; Foster 1959; Layne 1970; Smith and Speller 1970; Taylor and McCarley 1963; Tadlock and Klein 1979). Rosenzweig and Winakur (1969) suggest that arboreal habitats are important in promoting microsympatry in rodent assemblages, but the extent to which potential non-congeneric competitors affect habitat use by *Peromyscus* remains unclear. A majority of studies suggest that microtines aggressively dominate *Peromyscus* (Batzli 1968; Grant 1970, 1971; Pearson 1959; Shure 1970; Wirtz and Pearson 1960), although the outcome of species' interactions can be influenced by habitat familiarity and intraspecific social structure (Grant 1972). M'Closkey (1975, 1976) and M'Closkey and Lajoie (1975) showed that the distribution and density of White-footed Mice (*Peromyscus leucopus*) depended primarily on the structural configuration of habitat. M'Closkey and Fieldwick (1975) found no evidence of greater climbing activity of White-footed Mice at trap stations where they co-occurred with Meadow Voles (*Microtus pennsylvanicus*) but experimental verification of these field observations was lacking. Therefore, this experiment was designed to clarify the importance of arboreality in short-term interference competition between White-footed Mice and Meadow Voles under controlled conditions.

Methods

Two wooden cages, 1.8 × 1.2 × 1.8 m, of 0.64-cm^2 hardware cloth were assembled in an outdoor compound on the University of Western Ontario campus in May 1978. One cage was used as a control to monitor activity of White-footed Mice in the absence of Meadow Voles because activity varies seasonally, decreasing with decreasing temperature (Nicholson 1941; Thomsen 1945; Harland 1978). Dense natural vegetation, primarily grass with annual and perennial herbs and forbs, grew through the hardware-cloth floors of the cages. Woody arboreal habitat was constructed by arranging dead branches in each cage, with branch density, volume, and height of distribution approximately the same in both cages. Branch placement approximated natural conditions, i.e., thicker, horizontal branches, some laid flat to make "runways" used by White-footed Mice (M'Closkey 1975), were near ground level and higher branches were smaller and vertical. This interspersion of grassy and woody vegetation is characteristic of habitats where White-footed Mice and Meadow Voles are microsympatric (M'Closkey and Fieldwick 1975). Water was supplied, and grain and seeds were scattered liberally at ground level; some food was concentrated on areas of bare packed soil at the base of "trees". Three nest-boxes with cotton for nesting material were placed in each cage at heights of 0, 0.3, and 1.0 m. Observations of climbing behavior of White-footed Mice suggested that mice did not climb the hardware cloth with any greater frequency than the vegetation. Therefore, the assumption that climbing activity on the vegetation is representative of all climbing activity in the cage appears justified.

Preliminary tests indicated that pairs of mice (1 ♂ : 1 ♀) best survived extended period of time in the cages. Greater numbers and unisexual combinations resulted in fighting. Lab-reared White-footed Mice were introduced to each cage on 16 October 1978. Climbing activity of White-footed Mice was monitored in each cage for 5 d between 22 October and 1 November by

counting the number of distinguishable footprints on strips (2.5 × 15.0 cm) of smoked tracking paper (M'Closkey 1975) stapled around 26 randomly-selected branches in each cage. Tracking stations were marked and height above ground was recorded. All smoked cards were replaced each morning, yielding 260 card-nights of climbing activity data.

On 1 November, two laboratory-reared adult male Meadow Voles were introduced to the test cage and the climbing activity of White-footed Mice in both cages was monitored on 10 d, until 16 November, yielding an additional 520 card-nights of data. All test animals were retrieved in late December.

Results

White-footed Mice did not respond to the presence of Meadow Voles by increasing their arboreal activity. Overall climbing activity declined over the study period, and was not different between the test and control cages (Figure 1A). Also, track height distributions indicated that the activity of White-footed Mice shifted closer to the ground in the test cage (Figure 2A).

Two tests of significance of the decrease in climbing

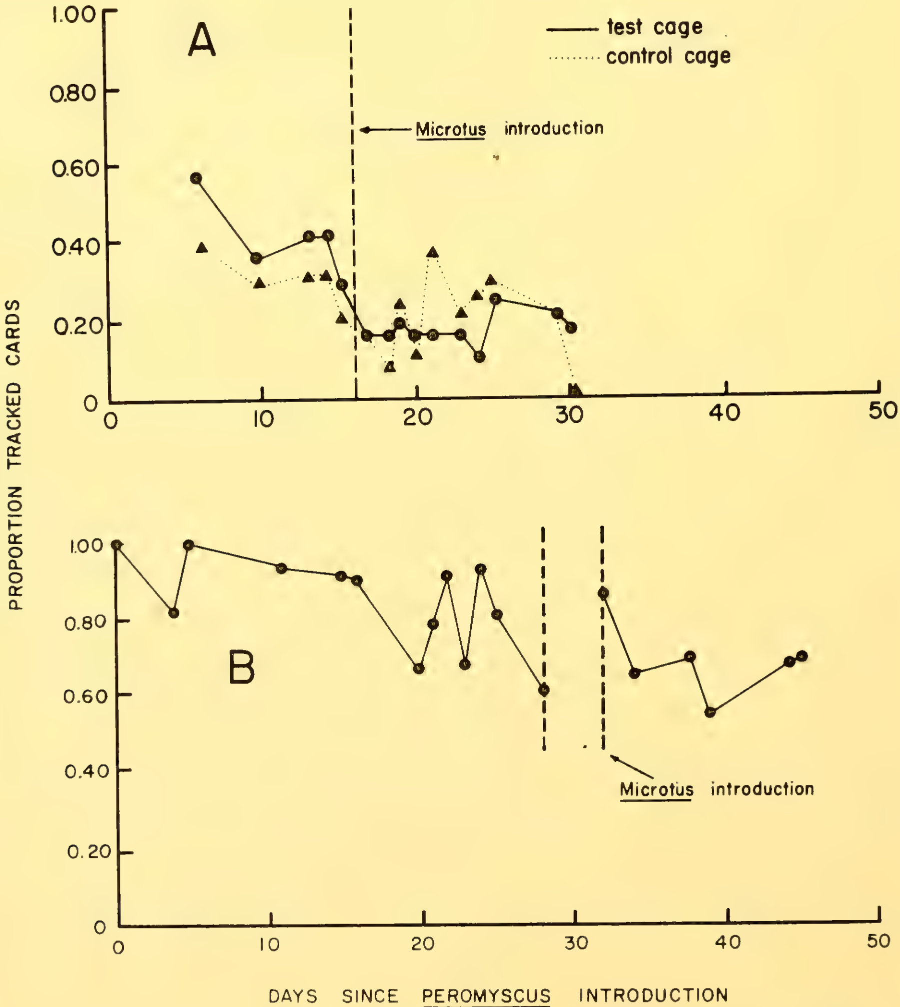

FIGURE 1. A, Changes in White-footed Mouse climbing activity with time in test and control cages before and after Meadow Vole introduction. B, As in A, from data collected in an earlier experiment (see Discussion).

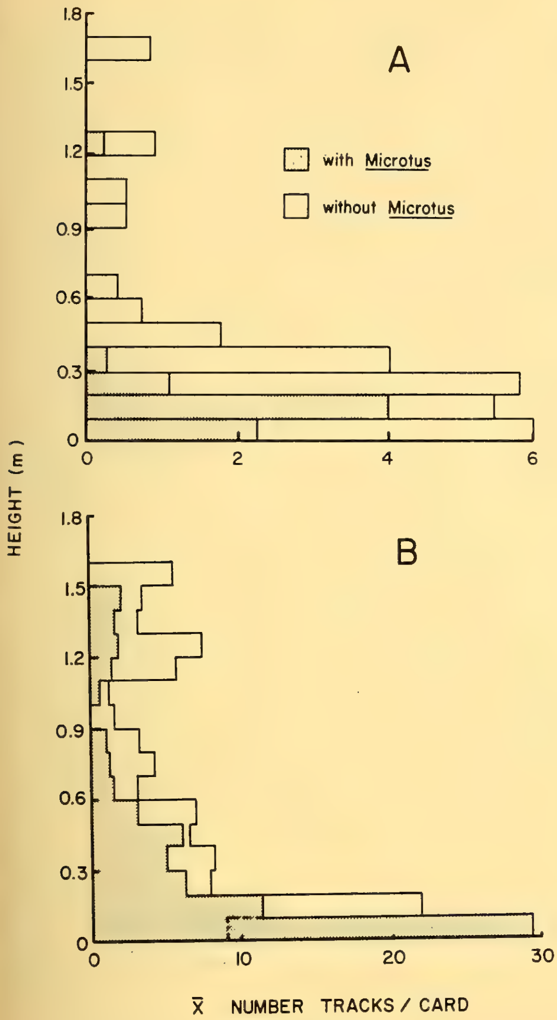

FIGURE 2. A, The vertical distribution of White-footed Mouse tracks in the test cage before and after Meadow Vole introduction. B, As in A, from data collected in an earlier experiment (see Discussion).

activity support the conclusion that White-footed Mice did not respond to Meadow Voles by increasing use of arboreal habitat. First, although a test of significance of the downward shift in track-height distribution (Figure 2A) was not appropriate because track-height distributions in each cage before the introduction of Meadow Voles were not similar (Kolomogorov-Smirnov test, $P < 0.01$), a two-way ANOVA indicated that the major source of variation in the number of cards tracked per night was not due to the presence of Meadow Voles, but rather to the period in which the data were collected ($P < 0.05$). Because mean daily temperatures decreased over the course of the experiment from 10°C to -5°C, it appeared that the White-footed Mice reduced activity with the onset of winter, as noted by Harland (1978), Nicholson (1941), and Thomsen (1945) regardless of the presence of Meadow Voles. Further, the decline in arboreality was independent of cage treatment (i.e., declines in each cage were parallel) as indicated by an insignificant interaction term in the ANOVA.

Second, it might be argued that the lack of an increase in mean height of tracks and the general depression of arboreal activity does not necessarily mean that arboreality is not a factor which may reduce interference interactions in this rodent species-pair because White-footed Mice were not tracked on the ground. If arboreality is a means for White-footed Mice to avoid interaction with Meadow Voles, however, then the proportional decrease in the mean number of tracks per card in the 0.0- to 0.1-m height category from before to after the introduction of the voles should have been greater in the test cage than in the control cage. There is no evidence to indicate that White-footed Mice shift activity away from ground level in response to the presence of Meadow Voles. (χ^2-test, $P >> 0.05$).

Discussion

Orr (1959) compared the activity of wild White-footed Mice with that of confined mice and found that orientation and adjustment of mice to the cage was quite rapid. He found no apparent differences between wild and confined mice in terms of the rate and manner of travel and reaction to objects. Harland (1978), using test conditions identical to those described here, concluded that enclosure activity was a reasonable replication of activity in the wild.

Schoener (1975, p. 248) postulated a continuum of mechanisms of habitat shift from behavioral through development to genetic. The results of this study confirm M'Closkey and Fieldwick's (1975) field observations that White-footed Mice climb vegetation regardless of the presence of Meadow Voles and short-term interference interactions appear to be unimportant in determining distributions. Rather these species are divergent in habitat use and diet (i.e., are nearer the 'genetic' end of Schoener's continuum), and co-occurrence is enhanced by habitat complexity which fulfills the niche requirements of both species (M'Closkey and Fieldwick 1975).

To what extent are the results presented here reproducible? Nudds (unpublished data) earlier monitored climbing activity by White-footed Mice in the presence and absence of Meadow Voles in a single cage on the campus of the University of Windsor for 19 d from 12 September to 27 October 1975. The cage

design and data collection procedure were as described here. Four wild-caught juvenile male White-footed Mice and two wild-caught adult male Meadow Voles were used, and natural day length and weather conditions prevailed for the experiment. The number of tracking stations varied. A total of 632 card-nights of data revealed the activity patterns shown in Figures 1B and 2B. Those patterns mirror the results of this analysis.

The possibility that arboreality may be a means of partitioning habitat at other times of the year than when these studies were done or when the potential competitor is taxonomically less "distant" (e.g., a congener) from White-footed Mice than are Meadow Voles remains to be considered. Although voles undergo a cycle of aggressive behavior synchronized with the breeding season (Turner and Iverson 1973), the former possibility seems remote because M'Closkey and Fieldwick's (1975) study spanned a breeding season. Evidence cited in the introduction suggests that the latter possibility is more apt to be realized in nature. Interspecific pairings among species in the genus *Peromyscus* in tests like those outlined here would be informative.

Acknowledgments

Duncan Innes, Bob M'Closkey, Doug Morris, and Bill Vickery commented critically on earlier versions of this paper. Lena Nudds helped collect data during the experiment done at Windsor.

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Numbers and Distribution of Caribou on the Boothia Peninsula, Northwest Territories

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Five aerial surveys were completed on Boothia Peninsula between 18 May 1974 and 27 March 1976. The population of Caribou (*Rangifer tarandus*) on the peninsula was estimated at between 561 and 626 in 1974. An apparent emigration of about 1000 Caribou, possibly from Prince of Wales Island, occurred sometime between summer 1974 and summer 1975. Population estimates in March of 1975 and 1976 were 1109 and 1120 Caribou, respectively. Caribou on Boothia Peninsula are migratory, wintering in the eastern and northeastern portions of the peninsula, and calving and summering in the northwestern and north-central portions. The distribution of Caribou appears restricted to the northern half of the peninsula. It is suggested that hunting pressure may be preventing re-establishment of Caribou on the southern half of the peninsula.

Key Words: Boothia Peninsula, Canada, Caribou, distribution, migration, Northwest Territories, population densities, *Rangifer tarandus*.

Ungulate population densities and distributions over large areas of the Canadian Arctic have been surveyed since the early 1960s. To date, however, no systematic surveys have been reported for the northern-most prominence of the Canadian mainland, Boothia Peninsula. The objective of this study was to determine the numbers and seasonal distribution of Caribou (*Rangifer tarandus*) on Boothia Peninsula.

Methods

Five aerial surveys were completed on Boothia Peninsula: in 1974, 18 May–20 June and 1–3 August; in 1975, 18–27 March and 5–12 June; in 1976 from 13–27 March. A Dornier D.O. 28 aircraft was used for virtually all of the aerial survey work, though it was supplemented with a Cessna 337 in June 1974. The primary operations bases were Resolute and Shepards Bay DEW Line station.

Surveys were of the linear transect type, and patterned after the methods of Miller et al. (1973). Predetermined, parallel transect lines were flown. The spacing of the transect lines was determined from the desired survey coverage. Animals were counted in 0.8-km strips on either side of the aircraft. Animals observed outside this strip were recorded separately as "off-transect." Markers were affixed to the aircraft in the line-of-sight of observers to indicate the location of the transect boundaries. Surveys through June 1974 were flown at 150 m above ground level to correspond with those of Miller et al. (1973) and to avoid potential stress to animals from aircraft disturbance in the critical spring period. Thereafter, survey altitude was reduced to 90 m as this height gave a better silhouette of the animals. The speed at which surveys were flown varied from 150 to 220 km/h.

Population estimates of Caribou were calculated by dividing the total number of Caribou observed on transect by the survey coverage (i.e., the proportion of the total area surveyed). Because of recurring bad weather conditions, the survey during May and June 1974 was divided into three strata. The population estimate from this survey was calculated separately for each stratum and then totalled. All other surveys considered the entire peninsula as a single stratum.

Results

Population estimates for the surveys are given in Table 1.

The seasonal distribution of Caribou on Boothia Peninsula is summarized in Figure 1. In March 1975, all Caribou observed were located in the northeastern half of Boothia Peninsula and most were on the flat, well-vegetated lowlands in the extreme northeastern corner between Cape Heytesbury and Cape Nordenskiold. Smaller numbers of Caribou were in the more rugged areas immediately south and west. In March 1976, most Caribou were again concentrated in the northeastern portion of the peninsula in the vicinity of Cape Nordenskiold. A lesser concentration was located in the highlands south of Cape Nordenskiold. No Caribou were found on the southwestern portion of the peninsula. Residents of Spence Bay, however, indicated that there were a few Caribou in the area of Josephine Bay and tracks were observed in that area during this survey.

TABLE 1. Population estimates of Caribou on Boothia Peninsula, 1974, 1975, and 1976

Stratum	Survey dates	% Coverage	Number observed: On transect	Number observed: Total	Population estimate	Density (no./100 km²)
I	18–25 May 1974	24.8	11	12	44	
II	7–9 June 1974	26.4	17	26	64	
III	19–20 June 1974	25.7	133	212	518	
	Total			250	626	1.9
	1–3 August 1974	9.8	55	71	561	1.7
	18–27 March 1975	9.2	102	146	1109	3.4
	5–12 June 1975	9.2	160	184	1739	5.3
	13–27 March 1976	20.7	232	343	1120	3.4

In May–June 1974 and June 1975, Caribou were distributed to the northwest in the rugged terrain between Pasley and Brentford bays. In late June and early July 1975, many Caribou were still concentrated in the extreme northwest, but large numbers were also observed in the north-central portion of the peninsula. One group of 352 animals, mostly cow-calf pairs, was observed approximately 45 km S of Wrottesley Inlet. In August 1974, Caribou were widely distributed over the entire northern portion of the peninsula.

Discussion

Although Banfield (1951) thought the Caribou population of Boothia Peninsula was about 2000 in 1950, there have been no previous aerial surveys to document accurately population numbers or distribution. In August 1959, A. H. Macpherson (1959, Canadian Wildlife Service unpublished report) conducted a brief aerial reconnaissance of the Spence Bay area; he flew 756 km over Boothia Peninsula but failed to observe any Caribou.

During the summers of 1974 and 1975, estimates of Caribou on Boothia Peninsula were 626 and 1739, respectively; the increase between years was threefold. Although it is possible that the discrepancy could be explained by survey error alone, we feel this is unlikely because of the agreement between population estimates obtained from the two surveys in 1974 (626 and 561 Caribou) and between the three subsequent surveys (1109, 1739, and 1120 Caribou). Thus, we believe that there was a movement of approximately 1000 Caribou onto Boothia Peninsula between summer 1974 and summer 1975. Further, because the late winter 1975 population estimate was twice as high as the summer 1974 estimate, animals most likely moved prior to March. An apparent decrease in numbers of Caribou on Prince of Wales Island during the same time period (C. A. Fischer and E. A. Duncan, 1976 report prepared for Polar Gas Project) suggests that Caribou may have moved eastward across Peel Sound to Boothia Peninsula. Similar population estimates in March 1975 and March 1976 suggest that little movement to or from Boothia Peninsula occurred during the winter 1975–76.

Inter-island movements of Peary Caribou (*R.t. pearyi*) have been reported to occur in the western Queen Elizabeth Islands, where it appears that high proportions of the Caribou population may seasonally range over two or more of these islands (Miller et al. 1977). Macpherson (*op. cit.*) suggested that crossings of Caribou have occurred between Boothia Peninsula and both Somerset and Prince of Wales islands. The frequency of movements of Caribou onto Boothia Peninsula and their significance to the Caribou population are unknown.

Our aerial surveys indicate that the Caribou on northern Boothia Peninsula are migratory. Wintering areas appear to be on the east and northeast portions of the peninsula, and calving and summering areas in the northwest and north-central portions.

We did not record Caribou south of a line running from approximately Thom Bay to Sanagak Lake and thence to Pasley Bay, despite the fact that Banfield (1951) reported the summer distribution of Caribou on the peninsula to be limited to a small triangular area bounded by Spence Bay, Thom Bay, and Lord Mayor Bay. Further, from a habitat-mapping program conducted on Boothia Peninsula for the Polar Gas Project in 1978 we concluded that some of the best Caribou habitat on the peninsula is in the area between Sanagak Lake and Spence Bay. But both Mair (1954, Canadian Wildlife Service unpublished report) and Macpherson (*op. cit.*) reported that Caribou had become exceedingly scarce in the Spence Bay area many years prior to the opening of the Hudson's Bay Company post in Spence Bay in 1947. Macpherson suggested, from his review of the historical records, that the Lord Mayor Bay and Thom Bay

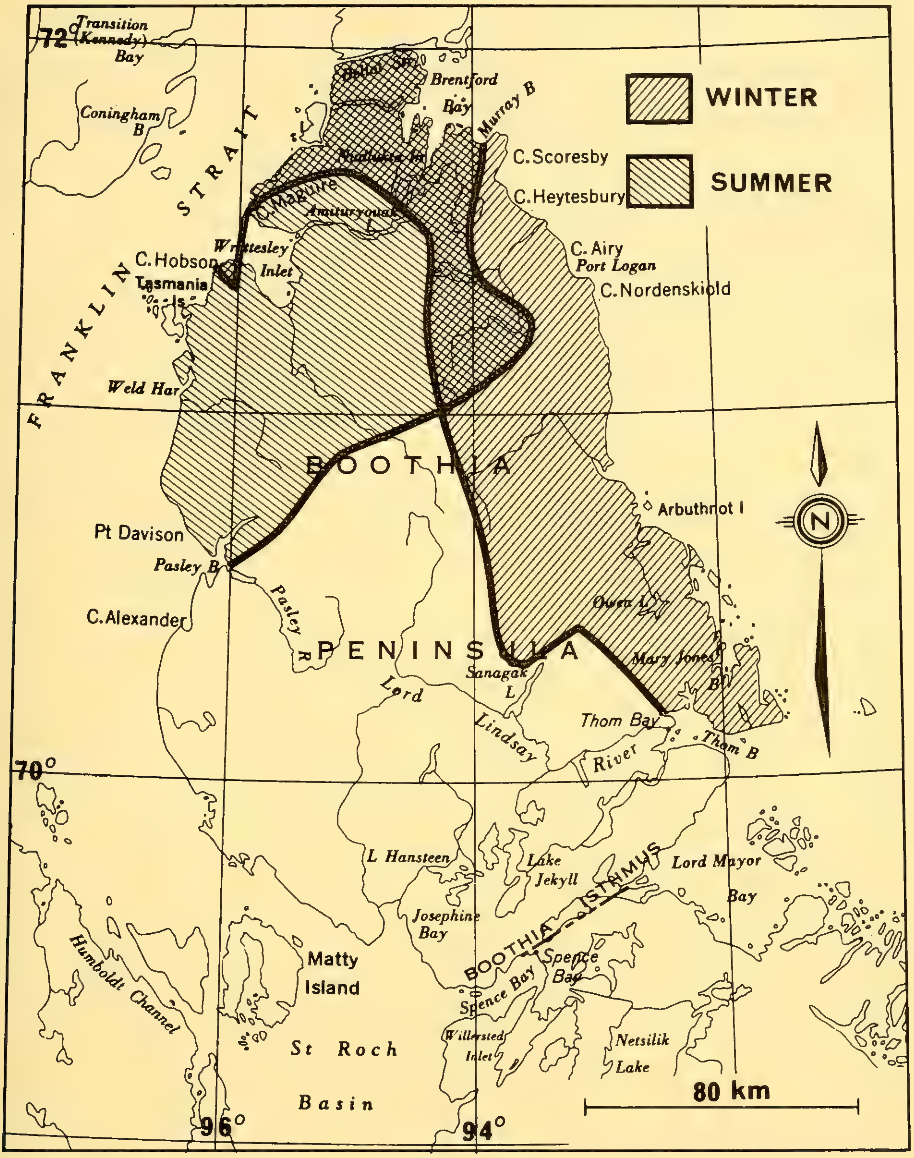

FIGURE 1. Distribution of Caribou on Boothia Peninsula from observations made during winter (March 1975, 1976) and summer (May–June 1974, June 1975, August 1975) aerial surveys.

areas were formerly the calving grounds of Caribou that migrated from the south and summered primarily around the large lakes of Boothia Isthmus. Resident Caribou herds were also reported to inhabit Boothia Peninsula; however, these resident Caribou were most common on the northern tip of the peninsula (Macpherson *op. cit.*). The unrestricted use of rifles for Caribou-hunting after the establishment of the Hudson's Bay Company post on King William Island in 1923 appears to have resulted in the reduction of the migratory portion of the Boothia Peninsula Caribou population (Treude 1975; Macpherson, *op. cit.*). The seasonal migrations of Caribou northward onto Boothia Peninsula probably ceased either in the

years between 1920 and 1930 (Macpherson, *op. cit.*) or during the mid-30s (Treude 1975). The resident herds to the north appear to have remained. Treude (1975) reported that the settlement processes that have occurred in the Boothia Peninsula region resulted in a continual constriction of the use of resource areas by the native population. By 1950, most of northern and central Boothia Peninsula had been essentially abandoned, and by 1969 only the Thom Bay – Spence Bay area was considered intensively used (Treude 1975). The areas reported to be most intensively used as resource areas since 1969 correspond well to the areas of current Caribou scarcity on Boothia Peninsula. We therefore speculate that current hunting pressure may be enough to prevent successful re-invasion of the Caribou habitat in southern Boothia.

Acknowledgments

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Notes

Hunting, Kill, and Utilization of a Caribou by a Single Gray Wolf

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Smith, Thomas G. 1980. Hunting, kill, and utilization of a Caribou by a single Gray Wolf. Canadian Field-Naturalist 94(2): 175–177.

A single wolf was seen killing a Caribou on the sea ice of a small bay on southeastern Baffin Island. The carcass of an assumed weight of 42 kg was totally consumed in approximately 46 h. Crude extrapolations are made indicating that one wolf might kill 28 or more Caribou per year to sustain itself.

Key Words: Gray Wolf, *Canis lupis*, Caribou, *Rangifer tarandus*, hunting, utilization, prey, predation, energy budget, arctic zone, Baffin Island, carnivores, nutritional requirements, feeding behavior.

During May to July 1978 I conducted a behavioral study of the Ringed Seal (*Phoca hispida*) at Popham Bay (64°17′N, 65°30′W) in the Lemieux Islands, eastern Baffin Island, Northwest Territories. The observation tent was located on the steeply-rising, northern edge of a small bay approximately 20 m above mean sea-level. Observations were generally made from 06:00 to 18:00 daily using binoculars and a 20–40× spotting telescope. The following account documents the kill of a Caribou (*Rangifer tarandus*) by a lone Gray Wolf (*Canis lupis*) on the sea ice near our observation area. The duration and degree of utilization of the carcass by the wolf were noted and some extrapolations are made concerning the food requirements of wolves dependent on Caribou.

At 10:50 on 24 May a lone wolf with distinctive back and flank markings, was observed to move onto the sea ice from the valley at the west end of the observation area. This wolf was later thought to be a male because of its stretching rather than squatting posture when urinating. It walked slowly eastward through the study area and was out of sight by 11:00, paying no particular attention to 11 Ringed Seals hauled up on the ice, although two seals were scared down by its presence.

From 15:05 to 16:55 the wolf was again in sight in the outer bay area. During this period it was observed to stalk and scare down three single and four pairs of Ringed Seals hauled out on the sea ice near their breathing holes. The wolf approached these seals slowly, stopping when they raised their heads to look about. Because of the distance from the observation point, an accurate measurement of how close the wolf got to the seals was not obtained. In two instances it appeared to get to within 20–50 m before the seals were scared down their breathing holes. At 15:40 the wolf appeared to lose interest in pursuing seals. It lay down on the ice, got up and howled several times, moving slowly and stopping several times before it disappeared up the valley at the west end of the observation bay at 16:55. As the wolf passed through the area two more seals were scared down their holes, even though the wolf did not stalk them.

The following day, 25 May 1978, the same wolf was first seen at 17:23 trotting quickly eastward along the sea ice of our observation bay, again coming from the direction of the valley to the west. The wolf glanced up towards the observation point several times and was out of sight around the northeast corner of the bay within minutes.

At 17:55 the wolf was again seen on the sea ice, approximately 2–3 km due east of the observation tent. It was in the process of killing a Caribou. When sighted, the Caribou was down on the ice and some movement remained in its head and front legs. The wolf was biting and pulling at the head and neck region of the Caribou, which soon ceased to move.

The wolf almost immediately began eating around the head and neck region. At 18:06 it was seen to be tearing hair out of the hind quarters and eating meat from that area. At 18:10 the wolf lay down beside the carcass. Two Glaucous Gulls (*Larus hyperboreus*) landed about 50 m from the kill, but made no move to approach it. At 18:18 the wolf curled up beside the carcass and appeared to sleep. This was interrupted by the arrival at 18:30 of a Common Raven (*Corvus corax*) which landed approximately 30 m from the kill. The wolf got up and chased the raven off. At 18:33 the wolf again curled up beside the carcass and slept. Observations were discontinued at this point.

On the way back to the camp from the observation tent I discovered a single fresh Caribou track. It was later found to have been the track of the Caribou pursued and killed by the wolf. The Caribou had been

chased for a considerable distance down the valley to the west of our bay and had turned uphill just before reaching our observation tent. We interpreted the spoor as indicating that the wolf had decided to intercept the Caribou by running along the sea ice. The Caribou was then killed either as it came off the land or was intercepted on the point by the wolf and chased out onto the sea ice. Our presence, which was probably known to the wolf from the previous day, may have influenced the path of pursuit.

Because of the distances involved and the fact that we did not want to disturb either the study area or the wolf kill, we did not ascertain whether the Caribou was a male or female. The track indicated that it was an animal of medium size. In my brief look at the head I did not see any antlers, indicating that the Caribou might have been a bull or a barren female since parturient females tend to retain their racks until after calving in June (Kelsall 1968).

At 06:55 on the following day, 26 May 1978, the same wolf was observed to be curled up and apparently sleeping beside the kill. At 07:30 it was up and eating from the carcass. At 07:58 the carcass was seen to be separated into two large parts lying approximately 2 m apart. At 08:05 the wolf began walking to the southwest with what appeared to be a shoulder and foreleg in its jaws. It had a noticeably distended stomach and moved west past our observation point until it disappeared into the rough ice on the south side of the bay.

The wolf was again sighted walking to the carcass at 18:00 at which time it began to eat immediately. A Common Raven and Glaucous Gull were seen eating from parts of the kill and later a Rough-legged Hawk (*Buteo lagopus*) landed and fed on parts of the carcass. The wolf was present at the kill when observations ended at 18:30.

On the following day, 27 May 1978, nothing was seen at the kill site until 13:45 when a raven and gull were noticed in the area. The carcass had been much diminished and was very hard to spot when nothing was feeding on it. At 15:10 the same wolf again appeared at the kill, walked about, and stretched to urinate on the ice near the carcass. From 15:15 to 15:40 the wolf fed on the remaining parts including the intestines. During that time it fed lying down near the remains. At 16:10 the wolf left the carcass, again moving west towards the valley at the end of the bay.

The wolf was not seen again in the area. The kill site could no longer be located with the telescope and I failed to locate it from the nearest point of land when I examined the area with binoculars. Daily observations between 06:00 and 18:00 were continued but no activity was seen at the kill site until a raven landed there briefly on 31 May 1978. Two gulls were seen there for a brief period again the following day, but after 1 June no more activity was noticed.

Wolves are not often seen to hunt on the sea ice. Indeed the unsuccessful attempts at stalking Ringed Seals during the haul-out period seems to indicate that this is an isolated incidence and probably not part of the productive hunting behavior of arctic wolves. In 10 yr of Ringed Seal studies I have never before noted any evidence of wolves hunting Ringed Seals on the sea ice. Stirling and Archibald (1977) record five instances of scavenging by wolves on seal carcasses left by Polar Bears (*Ursus maritimus*), and C. Jonkel (University of Montana, personal communication) noted the track of a single wolf stalking seals along a pressure ridge off southeastern Devon Island. Two instances of wolves stalking and possibly killing Ringed Seals at breathing holes, as seen by track evidence, were also recorded by M. Curtis (personal communication) in Tanquary Fiord, Ellesmere Island.

The attack and kill of a Caribou on the sea ice by a wolf has never to my knowledge been documented before. Indeed, few kills of Caribou have been observed by biologists. Crisler (1956) describes several kills of Caribou on the barren grounds in Alaska. In all cases more than one wolf was implicated and more than half of the kills were of crippled or sick Caribou. Kelsall (1968) noted that individual wolves seldom pursue if the Caribou runs and that successful kills usually result from ambush, relay running by several wolves, or in the confusion of an attack on a herd, where individual Caribou hinder one another's escape. Kuyt (1972) showed that 33% of Caribou mandibles found in the summer are of calves, whereas in the winter there appears to be a less skewed mortality regime.

The Caribou carcass in our study was apparently completely consumed by the wolf and a few avian scavengers over a period of approximately 46 h. It is probable that the wolf had cached the front leg and shoulder which it was seen to carry off. Because observations were not made through the night-time hours it is possible that the wolf might have cached more meat than just the front shoulder which we saw it carry off, but this is not thought to be the case. It is not possible to determine the exact amount of meat consumed by the two Glaucous Gulls and one Common Raven which were seen to feed intensely on the carcass during the absences of the wolf, but a rough estimate would be about 10 kg. The front shoulder, which was carried off to be eaten later by the wolf, probably weighed about 8 kg. Assuming an average carcass weight of approximately 43 kg for the smaller Caribou of Baffin Island (Banfield 1961), the remaining quantity of edible meat would be about 25 kg. Mech (1966) indicates that individual wolves feeding on

Moose (*Alces alces*) can consume upwards of 9.5 kg of meat in a 1.5-h session and cites two other instances of a wolf pack consuming 16.6 kg of Moose meat per wolf per day. In the present instance it appears that a lone wolf consumed 12.5 kg of meat in each of 2 d it utilized the kill. At the end of this time there appears to have been little edible remains left.

Some, admittedly tenuous, extrapolations might be made on the basis of this single observation. Kuyt (1972), from a combination of field observations and studies of captive wolves, estimated that one wolf would require 3.3 kg of meat per day, or 23 Caribou per year. This works out roughly to one Caribou every 16 d. Wolves in captive and wild situations are known to fast for periods of 1 wk to 10 d (Young and Goldman 1944; Mech 1966). The present account of carcass utilization, caching, and feeding indicates that a Caribou can be completely consumed in approximately 3 d by a wolf. If a 10-d fast is considered the maximum, then Kuyt's (1972) estimate of 23 Caribou annually might be somewhat low and a revised estimate of 28 Caribou per year might be more accurate. This might still be too low because later in the summer avian scavengers would consume more of the kill, especially in coastal areas where Common Ravens, Glaucous Gulls, and Iceland Gulls (*Larus glaucoides*) are abundant.

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New Records of Alpine Plants from Morfee Mountain, British Columbia

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Revel, Richard D. 1980. New records of alpine plants from Morfee Mountain, British Columbia. Canadian Field-Naturalist 94(2): 177–180.

Few botanical studies have been conducted in the northern portion of the Interior Alpine Zone of British Columbia. This study adds seven new vascular plants to the northern alpine flora from Morfee Mountain (55°26′N, 23°04′W) which lies in the northern portion of this subzone. These are *Lycopodium annotinum, Poa lanata, Carex brunnescens, Carex scopulorum, Luzula parviflora, Tofieldia pusilla,* and *Senecio lugens*.

Key Words: alpine plants, new records, British Columbia, northern flora.

The Alpine Tundra Biogeoclimatic Zone is widespread throughout British Columbia. Krajina (1969) divided the zone into two subzones: a Coastal Subzone characterized by a heavy cover and long duration of snow and an Interior Subzone characterized by relatively light snow cover with short duration. Although Krajina considered all Interior Alpine areas within one subzone, he noted that there is considerable variation from north to south both in species composition and elevation at which the Alpine Zone begins. Several studies have been conducted in the southern portion of the Interior Subzone (Chuang 1972; Hamet-Ahti 1965; Eady 1971); however, few exist documenting the vascular plant distribution in the northern part of the subzone.

The purpose of this study was to further phytogeo-

graphic knowledge of British Columbia's northern Interior Alpine Subzone. Of the 63 species collected, seven were new records and these are reported here. The complete list, however, is available at a nominal charge from the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2.

Study Area

The Alpine Zone of Morfee Mountain where I conducted the study lies in the northern part of the Interior Alpine Tundra Subzone. It is located on the north side of the Rocky Mountain Trench near MacKenzie, British Columbia (55°26′N, 123°04′W) (Figure 1). The Alpine Zone is bounded at lower elevation by the Engelmann Spruce – Subalpine Fir Biogeoclimatic Zone, while the river valleys surrounding the mountain are within the Subboreal Spruce Biogeoclimatic Zone (Krajina 1965; Revel 1972).

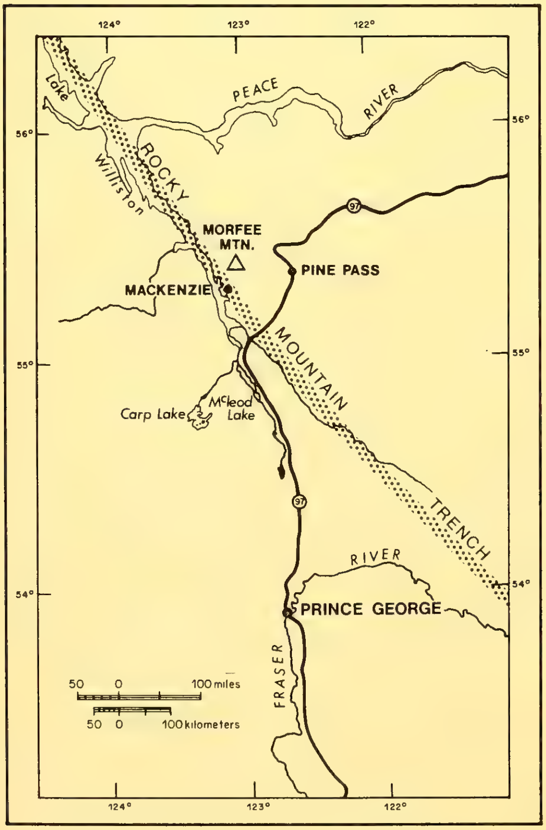

FIGURE 1. Location of the collection area at Morfee Mountain is indicated by the triangle on the map.

Morfee Mountain is of Precambrian and Paleozoic age and composed of primarily low-grade metamorphic rocks (Müller 1961). The southwestern slopes of the mountain contain primarily chlorite and sericite schist, phyllite, schistose grit, and quartz pebble conglomerate. The summit is typified by black slate which covers the ground, slaty greywacke, minor quartzite, and conglomerate. Cirques which form the headwaters of John Bennett Creek to the north are dominated by limestone and calcareous schist with minor slate and chlorite schist. Distribution of the vegetation reflects the geological composition of these units.

On the south-facing slopes the Alpine Zone begins at about 1370 m. There are few trees above this elevation except patches of krummholz *Abies lasiocarpa* (Subalpine Fir) which develop in small protected areas along draws and minor drainage courses.

On the basis of dominant cover species, I recognized seven plant groupings. Species nomenclature follows Hultén (1968).

1. *Rhododendron albiflorum – Abies lasiocarpa* community. This community is common at the interface area between the subalpine and the alpine areas. It is typified by a very high cover of *Rhododendron albiflorum* (White-flowered Rhododendron) interspersed with scattered semi-krummholz *Abies lasiocarpa*. Vegetation is strongly affected by snow creep, as shown by the notable downslope crook on *Rhododendron*. Other species include *Ribes lacustre* (Bristly Black Current), *Tiarella trifoliata* (False Mitrewort), *Athyrium filix-femina* (Lady Fern), *Galium triflorum* (Sweet-scented Bedstraw), *Erigeron peregrinus* (Wild Daisy), *Senecio triangularis* (Ragwort), and *Valeriana sitchensis* (Valerian).
2. *Orthocaulis floerkii – Abies lasiocarpa* community. This is the most common krummholz *Abies lasiocarpa* community and it is found almost exclusively along draws, minor drainage channels, or in small depressions where snow accumulates and soil moisture is relatively high. Krummholz *Abies lasiocarpa* forms a dense canopy with low light conditions at ground level. Angiospermous plants are not present. Two liverworts, *Orthocaulis floerkii* and *Barbilophozia lycopodioides*, dominate the ground and may ascend to the lower branches of *Abies*.
3. *Salix glauca – Alnus crispa* ssp. *sinuata* community. *Salix glauca* (Diamond Willow) and *Alnus crispa* ssp. *sinuata* (Green Alder) form dense stands at the interface zone between the upper subalpine and alpine. Other species within these stands include *Betula glandulosa* (Dwarf Birch), *Pedicularis bracteosa* (Lousewort), *Lycopodium annotinum* (Stiff Club-moss), *Castilleja miniata*

(Common Red Paint-Brush), *Galium triflorum*, and to a lesser extent, *Athyrium filix-femina* and *Luzula parviflora* (Wood Rush). *Sambucus racemosa* (Elderberry) is often present in the wetter seepage areas.

4. Upper Subalpine Flowering Meadow community. This community is typical of the subalpine-alpine interface in open areas where wind influence is moderate to low and seepage water keeps the soil fresh and moist. Dominant plants include *Valeriana sitchensis, Senecio triangularis, Veratrum viride* (False Hellebore), *Aconitum delphinifolium* (Monkshood), *Leptarrhena pyrolifolia* (Leather-leaved Saxifrage), *Erigeron peregrinus, Senecio lugens* (Black-tipped Ragwort), *Pedicularis bracteosa*, and *Castilleja miniata*.
5. *Phyllodoce empetriformis – Cassiope mertensiana* community. One of the most widespread communities in the study area, it frequently forms under late snow patches. Common plants include *Lycopodium alpinum* (Alpine Club-moss), *Luzula parviflora, Senecio lugens, Solidago multiradiata* (Dwarf Goldenrod), *Carex brunnescens* (Brownish Sedge), *Carex scopulorum* (Holm's Rocky Mountain Sedge), *Agrostis scabra* (Hair Grass), *Phleum commutatum* (Timothy), *Vahlodea atropurpurea* (Mountain Hair Grass), *Artemisia arctica, Lycopodium annotinum, Dryas octopetala* (Mountain Avens), *Phyllodoce aleutica* (Yellow Heather), and *Vaccinium uliginosum* (Bog Bilberry).
6. *Salix reticulata – Betula glandulosa* community. The community ranges widely in species composition and percentage of willow and birch cover. It is widespread throughout the Alpine Zone, from very dry to moist, well protected sites. The community forms a reticulate network between frost boils and areas of unstable ground. Other plants found in this unit include *Aconitum delphinifolium, Salix polaris, Salix arctica, Salix niphoclada, Draba cinerea* (Whitlow-grass), *Dryas octopetala, Sibbaldia procumbens, Gentiana propinqua* (Four Parted Gentian), *Campanula lasiocarpa* (Alpine Harebell), *Poa alpina* (Alpine Bluegrass), *Poa lanata* (Hairy Blue Grass), *Tofieldia pusilla* (Common False Asphodel), and *Festuca brachyphylla* (Sheep Fescue).
7. Low Alpine Shrub community. Common on gently undulating terrain exposed to high winds, the community is dominated by *Sibbaldia procumbens, Vaccinium uliginosum*, and *Empetrum nigrum* (Crowberry). *Silene acaulis* (Moss Campion), *Vahlodea atropurpurea, Phleum commutatum, Poa lanata*, and *Poa alpina* are also important community members.

New Alpine Records for Northern British Columbia

My collections were made during July 1969 as part of a study for the British Columbia Provincial Museum, and during August 1970 as part of an International Biological Programme investigation of Ecological Reserves. Specimens collected in 1969 were deposited at the British Columbia Provincial Museum (V) and those for 1970 were presented to the University of British Columbia herbarium (UBC). Specimens housed in the British Columbia Provincial Museum are identified in the list by collection numbers of T. C. Brayshaw and R. D. Revel. Nomenclature follows Hultén (1968).

Taylor and MacBryde (1977) documented the occurrence of vascular species in British Columbia according to the Biogeoclimatic Zonal scheme of Krajina (1965). Seven alpine species not listed in Taylor and MacBryde are reported here. The list includes records from the British Columbia Provincial Museum (V) of early alpine collections of these seven species that have not been previously reported in the literature.

Lycopodium annotinum 5113
Common in the *Salix glauca – Alnus crispa* community. Less common in the *Phyllodoce empetriformis – Cassiope mertensiana* community. Common throughout forested regions of province.

Poa lanata 5178A
Sporadic occurrences in the Low Alpine Shrub and *Salix reticulata – Betula glandulosa* communities. Previously reported from the Engelmann Spruce – Subalpine Fir Zone.

Carex brunnescens 5120
Sporadic occurrence in the *Phyllodoce empetriformis – Cassiope mertensiana* community. Previously reported only from Mountain Hemlock and Interior Hemlock Zones. Earliest alpine record in the British Columbia Provincial Museum Herbarium is from Apex Mountain at 2300 m elevation; collected by J. A. Calder and D. B. O. Savile in 1953.

Carex scopulorum 5121, 5135
Sporadic occurrence in the *Phyllodoce empetriformis – Cassiope mertensiana* community. Earliest alpine record in the British Columbia Provincial Museum Herbarium is from Mount Brent at 2300 m elevation; collected by J. W. Eastham in 1939.

Luzula parviflora 5119
Locally common in the *Salix glauca – Alnus crispa* community and sporadic in the *Phyllodoce empetriformis – Cassiope mertensiana* community. Previously reported from Mountain Hemlock, Coastal Hemlock, and Interior Hemlock Zones of British Columbia. An early alpine record is from the Paradise Mine near Windermere at 2600 m elevation; collected by G. A. Hardy in 1944.

Tofieldia pusilla
Sporadic occurrence in the *Salix reticulata – Betula glandulosa* community.

Senecio lugens 5144, 5180
Common in the Upper Subalpine Flowering Meadow Community and sporadic in the *Phyllodoce empetriformis – Cassiope mertensiana* community. Previously reported from forest zones of British Columbia.

Acknowledgments

I thank T. C. Brayshaw of the British Columbia Provincial Museum for his assistance in determining the plant specimens now housed in the British Columbia Provincial Museum.

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First Record of the Round Whitefish in Alberta

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Kristensen, John and Malcolm G. Foy. 1980. First record of the Round Whitefish in Alberta. Canadian Field-Naturalist 94(2): 180–182.

Two Round Whitefish (*Prosopium cylindraceum*) were captured in the Peace-Athabasca Delta, Alberta on 29 May 1977 and are the first recorded for the province.

Key Words: Round Whitefish, *Prosopium cylindraceum*, Peace-Athabasca Delta, Wood Buffalo National Park, Alberta record, geographical distribution.

The Round Whitefish (*Prosopium cylindraceum*), which is found in North America and Siberia, has a disjunct distribution in Canada (Scott and Crossman 1973). In eastern Canada it ranges from northern New Brunswick, Labrador, and Ungava west into parts of Quebec and Ontario and into the Great Lakes area. In western Canada it ranges from northern Manitoba and Saskatchewan, northwestward through the Northwest Territories, the Yukon Territory and into British Columbia. Between these two regions it has been reported in two isolated locations in northern Ontario.

Although the Round Whitefish has been reported in the Liard drainage of British Columbia, the Slave River in the Northwest Territories (immediately north of the Alberta border), and in the Saskatchewan portion of Lake Athabasca (Paetz and Nelson 1970), it has not previously been reported in Alberta. Because it has been reported in the eastern portion of Lake Athabasca in Saskatchewan as recently as 1971 (F. M. Atton, Saskatchewan Department of Tourism and Renewable Resources, personal communication), it is odd that the species has not previously been reported in the western portion of Lake Athabasca in Alberta. The presence of Round Whitefish in the Alberta portion of Lake Athabasca as shown on the distribution map by Scott and Crossman (1973) is apparently a result of an error in records (E. J. Crossman, Royal Ontario Museum, personal communication).

During the period 1975 to 1977, we conducted research in the Peace-Athabasca Delta, Alberta to assess effects on fishes of altered water regimes caused by the W. A. C. Bennett Dam in British Columbia

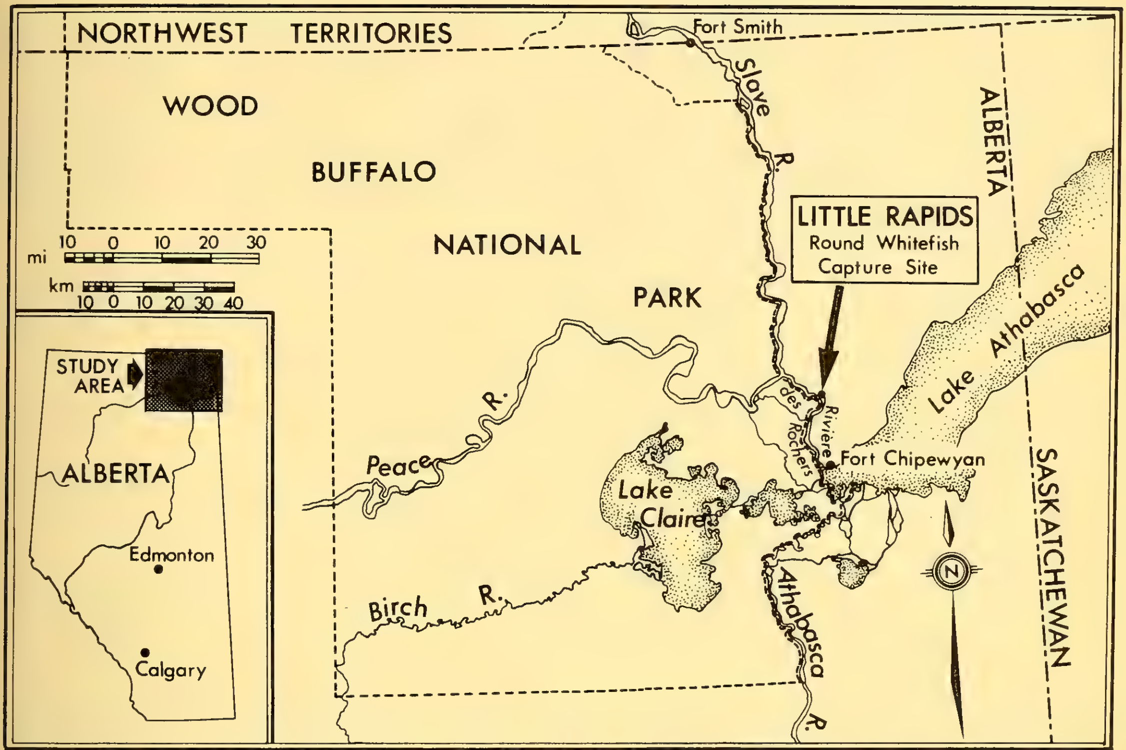

FIGURE 1. Location where first Round Whitefish in Alberta were captured.

and by remedial structures subsequently built in the Delta (Kristensen et al. 1976; Kristensen[3]; Kristensen and Summers 1978). Fishing with variable-mesh gill-net gangs was conducted for approximately 550 man-days and approximately 36 000 fishes (species combined) were captured during the 3-yr period. On 29 May 1977 we captured two Round Whitefish at Little Rapids on the Rivière des Rochers along the eastern boundary of Wood Buffalo National Park (Figure 1). Both fish were captured in a 6.4-cm monofilament nylon gill net set in approximately 5 m of water. The river is approximately 275 m wide at Little Rapids and on 29 May 1977 the water was at 13°C, extremely turbid, and flowing rapidly toward the Peace River.

One of the Round Whitefish was tagged and released; the other was preserved and deposited at the Department of Zoology Museum, University of Alberta (collection number UAMZ 3779). Immediately following capture the former weighed 340 g and was 324 mm in fork length and 356 mm in total length; the preserved fish, a mature female, weighed 312 g and was 336 mm in fork length and 361 mm in total length. On the basis of scale readings, the preserved fish was 8 yr old.

Both fish were captured immediately downstream (northwest) of a submerged weir constructed across the Rivière des Rochers. At this time, large numbers of fishes of other species, primarily Goldeye (*Hiodon alosoides*), were concentrated downstream of the weir. High water velocities (2.1 m/s) across the weir probably hindered fishes, including the Round Whitefish, from moving upstream. These data suggest that the two Round Whitefish captured at Little Rapids were travelling toward Lake Athabasca from the Slave River, and possibly from the Northwest Territories where this species has been reported previously.

We thank H. Marten for assisting us in the field; J. S. Nelson and W. Roberts for confirming the identification of the fish; J. S. Nelson, W. Roberts, and W. J. Richardson for providing valuable comments on a draft of this note; and K. Bruce for preparing the figure. The research was conducted under contract by

[3]Kristensen, J. 1978. Investigations of Goldeye and other fish species in the Wood Buffalo National Park section of the Peace-Athabasca Delta, 1977. Report prepared for Fisheries Subcommittee, Peace-Athabasca Delta Monitoring Committee by LGL Limited. 108 pp.

LGL Limited; funds were provided by the Canadian Department of Fisheries and Environment and were administered by the Alberta Department of the Environment, Research Secretariat.

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Great Blue Heron Colonies in Northwestern Ontario

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Gray, Paul A., James W. Grier, George D. Hamilton, and D. Paul Edwards. 1980. Great Blue Heron colonies in northwestern Ontario. Canadian Field-Naturalist 94(2): 182–184.

An aerial survey during July 1978 sampled the breeding range, colony size, and habitat preference of the Great Blue Heron (*Ardea herodias*) north of the previous known range in western Ontario. The most northerly colony found was at latitude 54°12′N. Eight of 14 new colonies were on lake islands. Herons preferred tall Jack Pines (*Pinus banksiana*) as nest sites. The mean colony size was 8.5 (range 4–16) nests, and the mean number of successful nests per colony was 6.3 (range 3–15).

Key Words: Great Blue Heron, *Ardea herodias*, heronries, Ontario, aerial survey, breeding range, new records, habitat.

Little information has been collected on breeding range, colony size, and habitat preference of the Great Blue Heron (*Ardea herodias*) near the northern limits of its range in Ontario. Elsewhere in Canada, surveys have been completed in the lake regions of Alberta, Saskatchewan, and Manitoba (Vermeer 1969, 1970, 1973; Vermeer and Anweiler 1970; Vermeer and Hatch 1972), and in Nova Scotia (McAloney 1973). This study was designed to examine breeding range, colony size, and habitat preference of the Great Blue Heron in northwestern Ontario.

Study Area

The colonies were located on the Canadian Shield within the limits of the boreal forest region (Rowe 1972). Geography and climate of this area have been described by G. A. Hills (1959. Ontario Department of Lands and Forests unpublished report), Zoltai (1961), and Chapman and Thomas (1968). Fire and, to some extent in the south, logging have played important roles in shaping the landscape, which can be described as a heterogeneous mosaic of forests in various stages of succession.

Methods

The survey was conducted in conjunction with a study of the distribution and abundance of the Bald Eagle (*Haliaeetus leucocephalus*). Initially an aerial search of the shoreline of more than 2500 bodies of water was completed using Piper Cub and Supercub aircraft. Subsequently, heron colonies located during the aerial survey and from reports submitted by field staff were examined from a Bell Long Ranger helicopter. Detailed information on colony size and nest-site selection from 11 of the 14 colonies was collected from the helicopter. Two of the 11 colonies were also checked from the ground.

This survey was conducted on warm days during July 24–26 when the young were near fledging. We found that disturbance was minimized at a horizontal distance of 100–200 m from the colony, and at an altitude of 50 m. Binoculars or a spotting scope were best used for observation at this range.

Results and Discussion

Breeding Range

Locations of the Great Blue Heron colonies are

shown in Figure 1. The most northerly colony found was near an unnamed lake at 54°12′N. The northern limit of the reported breeding range of the Great Blue Heron in Saskatchewan and Manitoba coincides approximately with the southern edge of the Canadian Shield. A few small heron colonies have been reported from Shield areas, e.g., Talbot Lake (54°07′N, 99°53′W) and Many Bays Lake (52°40′N, 97°00′W), Manitoba (Vermeer 1973). Those colonies were considerably north of the breeding range given by Godfrey (1966), as were all 14 colonies in our study area. Great Blue Herons have also been observed on Charlton Island, James Bay (H.G. Lumsden, Ontario Ministry of Natural Resources, personal communication). It seems possible that the breeding range extends across Ontario to the northern limits of the boreal forest.

Habitat and Nest-site Selection

Eight of the 14 colonies were on lake islands (Table 1). All but two colonies were at the water's edge. The herons nested in Jack Pine (*Pinus banksiana*) or in Black Spruce (*Picea mariana*) — White Birch (*Betula papyrifera*) associations. Two colonies were entirely in living Jack Pine with the remaining nine situated in mixtures of dead, dying, and living trees (Table 2). The colonies entirely in living Jack Pine were small (well below the average colony size in this area), suggesting that they were newly established and had not yet progressed to a point where heron guano had begun to kill the trees.

Miller (1944) hypothesized that an adequate food supply and suitable nesting habitat are the two prime

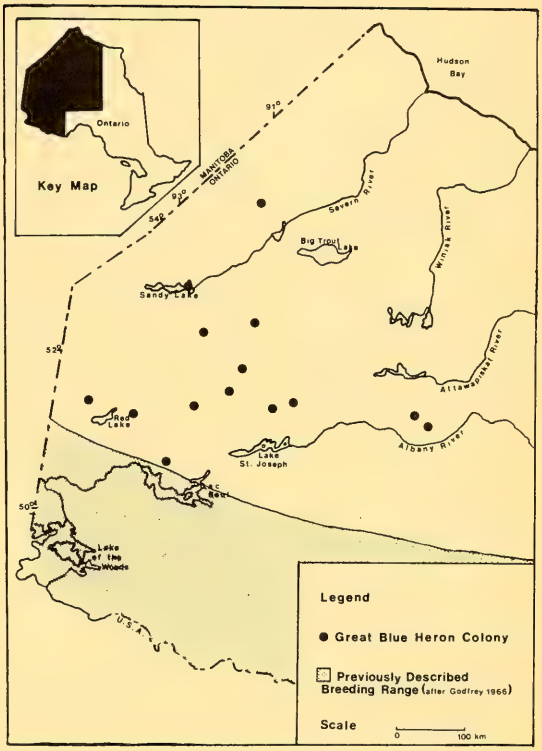

FIGURE 1. Map of northwestern Ontario, illustrating the location of new-found Great Blue Heron colonies. The stippled area represents the previously described breeding range, after Godfrey (1966).

TABLE 1—Location and habitat type of active Great Blue Heron colonies observed in northwestern Ontario, 1978

Location of colony		Primary nest-tree species	No. of nests	No. of successful nests
51°45′N, 92°03′W	Shoreline	Jack Pine	16	15
51°30′N, 92°36′W	Island	Jack Pine	5	4
50°43′N, 92°33′W	Shoreline	Jack Pine	4	3
51°02′N, 93°02′W	Shoreline	Jack Pine	8	6
51°22′N, 94°00′W	Shoreline	Jack Pine	11	4
51°43′N, 90°16′W	Island	Black Spruce, White Birch	9	8
51°19′N, 90°56′W	Island	Black Spruce, White Birch	4	3
53°03′N, 92°43′W	Island	Black Spruce, White Birch	4	3
52°49′N, 91°24′W	Island	Black Spruce, White Birch	12	6
52°18′N, 92°20′W	Near river	Jack Pine	9	7
51°59′N, 91°23′W	Island	Jack Pine	11	10
54°12′N, 91°23′W	Inland	Unknown	—	—
51°40′N, 87°32′W	Island	Unknown	—	—
51°37′N, 87°27′W	Island	Unknown	—	—

TABLE 2—Tree habitat of active Great Blue Heron colonies in northwestern Ontario, 1978

Dominant nest-tree species	Condition of nest trees			Estimated average tree height		
	No. of colonies	Trees[a] alive	Trees dead	10–13 m	14–17 m	> 17 m
Jack Pine	7	38	26	0	1	6
Black Spruce–White Birch	4	7	20	1	3	0

[a]Many of these trees were dying.

factors that determine distribution and abundance of herons. He believed that the type of tree available for nesting was less significant than its height and distance from disturbance. Palmer (1962) and Henny (1978) reported that Great Blue Herons sometimes nested on man-made structures in isolated locations. In our study area all of the colonies were totally isolated from human presence.

In 10 of the 11 colonies examined, nests were in trees estimated to be at least 14 m in height. Preference for tall trees is probably in response to visibility, ground predators, and flight access for entering, leaving, and escaping the nests. Because there is no lack of suitable nesting habitat in the study area, selection of colony location is likely dependent upon proximity to suitable feeding areas.

During a ground survey, one nest that had remained intact in a fallen Black Spruce tree was examined. The nest was constructed of coarse sticks, twigs, and herbaceous plant stems, and was cemented together by excrement, presumably accumulated over many seasons.

Colony Size

The mean size of heron colonies was 8.4 nests (range 4–16, n = 11; Table 1). Of 93 nests observed, 69 (74%) were successful, a successful nest being one in which at least one nestling was observed, all nestlings being an estimated 6–8 wk of age during the survey. The mean number of successful nests in each colony was 6.3 (range 3–15, n = 11).

Vermeer (1970) reported that colonies on islands in Lake Winnipegosis, Manitoba, and adjacent lakes were significantly larger ($P < 0.01$, $\bar{x} = 57$ nests, range 3–170) than colonies in Alberta ($\bar{x} = 21.3$ nests, range 1–55). He speculated that this difference might be due to exceptional feeding habitat found in Manitoba lakes. By comparison, colonies in our study area were much smaller than those found further south in Canada and in the United States.

Acknowledgments

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Snow Buntings, Lapland Longspurs, and Other Passerines in Davis Strait and Labrador Sea, 1977–1979

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Orr, Craig D., David J. Gillis, and Linda G. Valdron. 1980. Snow Buntings, Lapland Longspurs, and other passerines in in Davis Strait and Labrador Sea, 1977–1979. Canadian Field-Naturalist 94(2): 185–187.

Passerine birds were recorded in southern Davis Strait and northern Labrador Sea (59–66° N) during eight cruises in 1977 and 1978, and from a stationary drillship from 10 July to 7 October 1979. Most spring sightings in April and May were of Snow Buntings (*Plectrophenax nivalis*), which were apparently migrating from North America wintering areas to southwest Greenland breeding sites. A limited fall migration was witnessed for Snow Buntings, and a more pronounced movement was observed for the Lapland Longspur (*Calcarius lapponicus*) from late August to mid-September 1979. Two species of North American wood warblers were also recorded in June 1977 in northern Labrador Sea.

Key Words: Snow Bunting, *Plectrophenax nivalis*, Lapland Longspur, *Calcarius lapponicus*, Davis Strait, Labrador Sea, passerine migration.

During 1977–1979, seasonal data on seabirds were collected in southern Davis Strait and northern Labrador Sea (59°–66°N) during environmental studies sponsored by a consortium of oil companies. Ten-minute watches were made from moving or stationary platforms, as described by Brown et al. (1975) in the Programme Intégré de Recherches sur les Oiseaux Pélagiques (PIROP). Observations were made during eight cruises of the *Lady Johnson II* in 1977 and 1978, and daily watches from 10 July to 7 October 1979 from the drillship *Ben Ocean Lancer* anchored in Davis Strait at 62°11′N, 62°58′W. This note describes observations of passerine birds primarily from the undocumented spring and fall periods.

Spring Migrants

The timing of the cruises in 1977–1978 is shown in Table 1. During spring, the Snow Bunting (*Plectrophenax nivalis*) was the most commonly encountered passerine, with 38 birds observed in April and May (Figure 1) during PIROP observations in Davis Strait (235) and northern Labrador Sea (60). Several Snow Buntings were also sighted between watches in these months. These birds were presumably migrants cross-

TABLE 1—Observation dates, number of 10-min watches, and birds observed during 1977–1978 cruises (59°–66°N) and 1979 drillship operations (62°11′N, 62°58′W), southern Davis Strait and northern Labrador Sea

Observation dates	Number of 10-min watches	Number of birds: Snow Bunting	Lapland Longspur
1977			
7–19 February	89	0	0
27 April–17 May	71	8	8–13
8–24 June	184	0	0
1 August–30 September	192	0	3
11 October–6 November	114	1	0
10 November–9 December	66	0	0
1978			
15 April–18 May	224	30	2
12–23 August	24	0	0
1979			
10–31 July	439	0	0
1–31 August	370	0	13
1–30 September	313	6	41
1–7 October	42	0	2

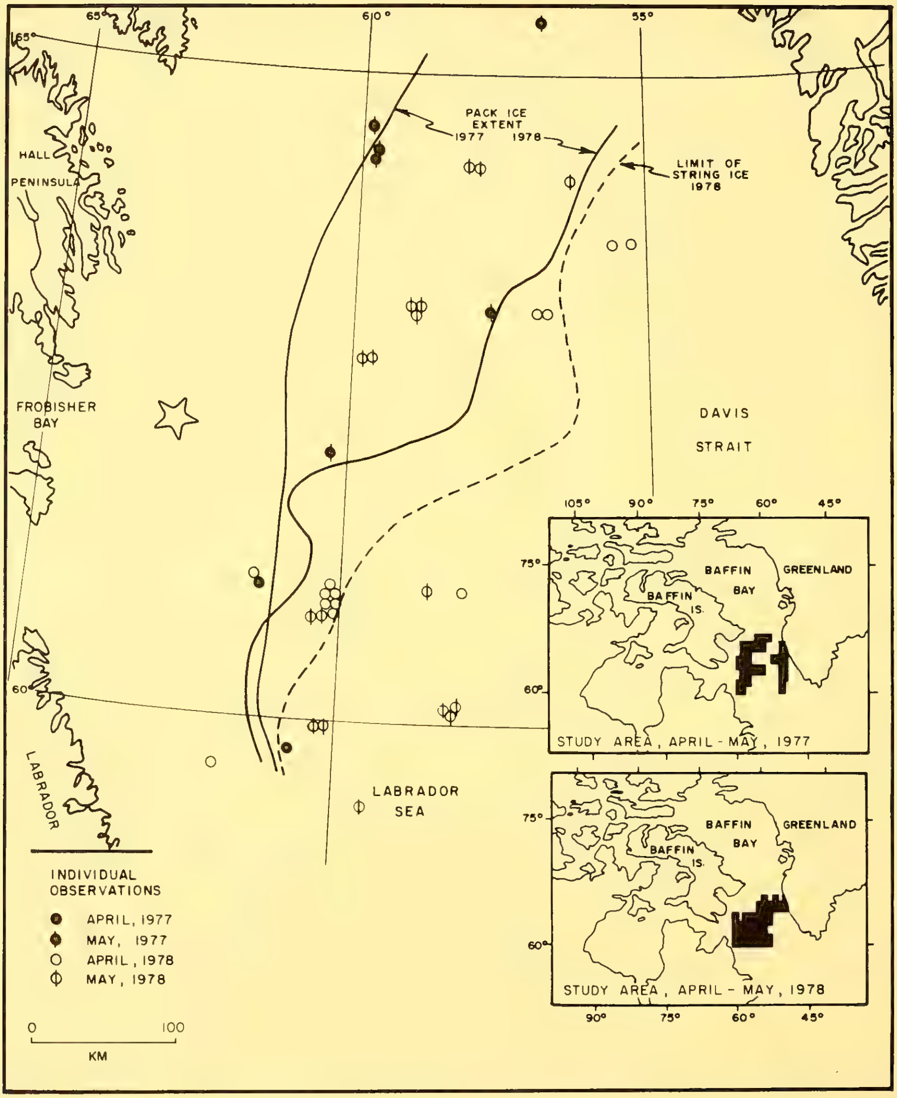

FIGURE 1. Observations of Snow Buntings in southern Davis Strait and northern Labrador Sea during 295 PIROP watches in April and May 1977–1978. Large star shows 1979 drillship location.

ing Davis Strait from Canada to West Greenland, judging by banding returns (Nethersole-Thompson 1966).

Most observations were near the edge of extensive pack ice (Figure 1), where birds were often sighted resting on the ship or ice pans. The locations of the observations are compatible with a northeasterly movement of the birds across Davis Strait. In the Labrador Sea south of 59°N, only two Snow Buntings were seen during 140 PIROP watches in April and May. The ship did not penetrate far enough west into the pack ice to determine whether there was a movement north along the Labrador coast.

Snow Buntings were present when the vessel arrived both years, with the earliest record on 16 April 1978. This common Greenland breeding bird usually arrives in West Greenland during early April (Salomonsen 1950). First arrivals are usually males (Williamson *in* Nethersole-Thompson 1966), and during the two Aprils, at least 13 of the 15 birds observed were males.

The latest spring record was 18 May 1978 in the northern Labrador Sea. Migration regularly lasts more than one month, usually terminating in late May (Williamson *in* Nethersole-Thompson 1966).

Another possible migrant seen in offshore waters was the Lapland Longspur (*Calcarius lapponicus*). A total of 10–15 individuals was observed during April and May 1977–1978 (Table 1). A single redpoll (*Carduelis* sp.) was also observed on 30 April 1977.

Fall Migrants

Fall observations of Snow Buntings were decidedly fewer than in spring. The single observation from the *Lady Johnson II* was on 18 October 1977 at 62°42′N, 62°18′W (Table 1). Six Snow Buntings were seen during 313 PIROP watches in September from the drillship, with single sightings on 8, 12, 13, 16, 18 and 19 September. D. Stone (personal communication) also sighted five Snow Buntings in Davis Strait on 16 September 1979, while aboard the icebreaker *Canmar Kigioriak*. These birds were seen while the boat was cruising north from 63° to 66° N and between 58° and 60° W.

If these few records indicated a return fall migration across Davis Strait, Baffin Island would be a possible first landfall. The possibility of another migration route from Greenland was proposed by Williamson (*in* Nethersole-Thompson 1966) who stated that "... weather conditions on the North Atlantic permit the south-west Greenland birds to winter in America in most years, but sometimes compel them to travel to Europe instead." Recently, Spencer and Hudson (1978) documented a Scottish recovery of a Canadian banded bird that was a possible Greenland breeder. More fall sightings from Davis Strait are needed to determine when and where a return fall crossing is made.

The most numerous fall migrant was the Lapland Longspur. At least 52 individuals were sighted from the drillship on 14 different days from 27 August to 16 September 1979, with other records on 30 September (2) and 5 October (2). Most sightings were of one or two individuals, with the largest daily totals of 23 on 4 September and 9 on 31 August. Lapland Longspurs were attracted to the drillship, and most were counted when they landed on or circled the vessel. This may have increased totals, so only single highest daily counts were used. As the vessel was only about 75 km off the Baffin Island coast, the observed migration may have been largely of Canadian breeders and not trans-Davis Strait migrants. The remaining fall migrants were seen on 25 (1) and 30 (2) August 1977.

Additionally, single Water Pipits (*Anthus spinoletta*) were sighted on 3 and 4 September 1977, and 27 August, 13 and 15 September 1979.

Miscellaneous Records

Probable strays included a male Yellow-rumped Warbler (*Dendroica coronata*) and a Tennessee Warbler (*Vermivora peregrina*) shown to observers by the ship's crew. These birds had landed aboard the vessel around "mid-June" in northern Labrador Sea, and were kept as pets for 3–5 d. Surprisingly, the Yellow-rumped Warbler has been recorded six times in southwestern Greenland, and the Tennessee Warbler once (Salomonsen 1967).

Two additional fall warbler sightings made in mid-northern Labrador Sea by observers on an Acadia University Arctic cruise aboard *H.M.C.S. Preserveur* (P. C. Smith, personal communication) included a Magnolia Warbler (*D. magnolia*) on 6 September (ca. 59°10′N, 56°00′W) and a Yellow-rumped Warbler on 9 September 1977. Tingley (1978) recently recorded the Magnolia Warbler in Cumberland Sound, Baffin Island.

Acknowledgments

Permission to publish observations from the *Lady Johnson II* was generously provided by ESSO Resources Canada Ltd., Aquitaine Co. of Canada Ltd., and Canada Cities Services Ltd. Dome-Canmar allowed the use of observations made aboard the *Canmar Kigioriak,* and T. Beck of Aquitaine provided the observations from the *Ben Ocean Lancer.* D. P. Stone, J. A. Booth, J. E. Brownlie, G. D. Greene, and S. A. M. Conover were observers on various cruises and E. Peters, E. Joamie, B. Etooangat, and N. Onalik made most of the observations from the drillship. We also thank D. P. Stone, B. C. Jones, and L. G. Curtis for helpful suggestions on the manuscript.

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Sedum divergens, New to the Flora of Alaska

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Murray, David F. 1980. *Sedum divergens,* new to the flora of Alaska. Canadian Field-Naturalist 94(2): 188–189.

Key Words: *Sedum divergens*, flora, Alaska, new records.

The discovery of *Sedum divergens* in southeastern Alaska at Mile 10 on the Haines Highway (59°18′N, 135°42′W) by Robert B. Weeden brought to my attention another specimen of this species from the same locality that was collected in 1967 by Leslie A. Viereck (*Viereck 8597*, ALA) but which went unreported. Thus, now we have at hand two specimens to document this species in the flora of Alaska. Although the distribution map for *S. divergens* in the monographic treatment of the genus by Clausen (1975, Figure 76) shows an Alaskan locality, that dot was misplaced and was intended to represent a Graham Island, British Columbia, record (Clausen, personal communication, 1976). From Weeden's report to me and from the label data accompanying the Viereck specimen, we know it is found near Haines on a dry south-facing slope near sea-level in association with Lodgepole Pine (*Pinus contorta*).

Sedum divergens is otherwise found isolated in the Klamath Mountains of northwestern California and southwestern Oregon, throughout the middle and northern Cascade Mountains north of 43°N, the Olympic Mountains of Washington, and in both the coastal mountains and the interior ranges and plateaus of British Columbia as far north as 56–57°N (Clausen 1975). The Alaskan locality is disjunct from the main range by about 700 km (Figure 1), but *S. divergens* should be looked for in the Alaskan "panhandle" south of Haines and in coastal British Columbia.

In the southern part of its range and at least as far north as northern Washington *S. divergens* is found in subalpine and alpine sites up to 2288 m (Mount Ranier). Yet in the Queen Charlotte Islands, British Columbia, this species is restricted to dry rocky headlands and bluffs at sea-level (Calder and Taylor 1968). Similarly, at Haines, Alaska, *S. divergens* is found on a steep rocky slope near sea-level.

This species is one of only two in the genus with decussately opposite leaves; the other, *S. debile*, is restricted to the Great Basin and central Rocky Mountains. The thick, terete, and suborbicular opposite leaves of *S. divergens* are conspicuous; consequently it should be easily distinguished (Figure 2).

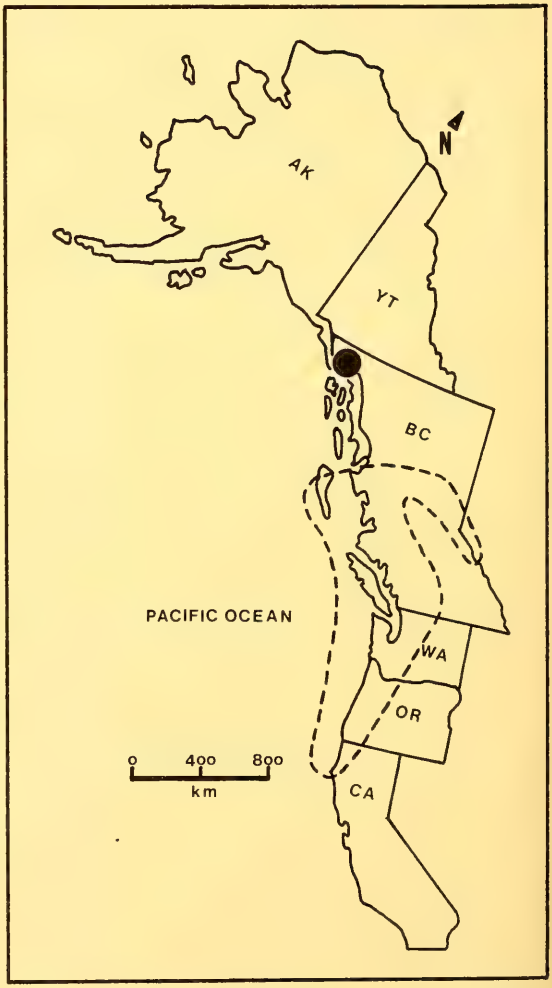

FIGURE 1. Map showing with dashed outline the main range of *Sedum divergens* (see text) and with a closed circle the new locality for it at Haines, Alaska.

The chromosome number of 2n = 16 for the Alaskan population (Dawe and Murray 1979) is consistent with the reports by Clausen (1975) and Uhl (1977). The report of 2n = 28 given by Hitchcock et al. (1964)

FIGURE 2. *Sedum divergens*. The bar scale indicates 10 mm. Note the decussately opposite leaves.

is apparently based on a count by Baldwin (1935) which was actually made on material of another species (Taylor and Mulligan 1968).

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Northern Phalarope Breeding in Alberta

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Höhn, E. Otto and David J. Mussell. 1980. Northern Phalarope breeding in Alberta. Canadian Field-Naturalist 94(2): 189–190.

Key Words: Northern Phalarope, Alberta, confirmed breeding.

Male Northern Phalaropes (*Lobipes lobatus*) had been observed at a small unnamed lake 1.5 km W of Rocky Island Lake (59°06′N, 115°17′W) in the Caribou Mountains of northern Alberta, in late June of 1973 and 1975 (E. O. Höhn and R. B. Burns, Blue Jay 1975 33: 73–82). On both occasions, the birds be-

haved in a manner suggesting they had young nearby, although none were found.

Breeding of this species was finally proved on 26 June 1979 when, on the same lake, we observed a male which attended a single egg. The egg was found in the open, lying on sphagnum moss, with a fragment of another egg-shell nearby, 10 m from the lakeshore. The habitat was clumps of moss among scattered tufts of dead grass and small Black Spruces (*Picea mariana*). We assume that a predator had raided the nest and dropped the intact egg nearby. The phalarope was apparently incubating the displaced egg. An empty phalarope nest is difficult to identify, but a probable nest site in a grass tuft about 6 m from the egg was visited by the bird. The above evidence confirms breeding by this species in Alberta, well to the south of its main breeding range.

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Winter Mortality in a Gray Partridge Population in Manitoba

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Knapton, Richard W. 1980. Winter mortality in a Gray Partridge population in Manitoba. Canadian Field-Naturalist 94(2): 190–191.

Numbers of Gray Partridge on a study area in southwestern Manitoba declined from 43 in October to 23 in March. One storm was responsible for 70% of the total over-winter loss.

Key Words: winter mortality, Gray Partridge, Manitoba, population dynamics.

Gray Partridge (*Perdix perdix*) reportedly suffer little mortality during winter in some regions of North America with long and severe winters, such as the Canadian prairies (Westerskov 1965; H. M. Hunt, unpublished data). Reports that combinations of snow, wind, and prolonged low temperatures can cause some losses in winter have frequently been anecdotal and without quantitative data (Yocom 1943; McCabe and Hawkins 1946). This note reports the effect of a severe winter storm on a local population of partridges.

The study area was 530 ha of agricultural land interspersed wth hedgerows and clumps of Trembling Aspen (*Populus tremuloides*), near Lyleton in extreme southwestern Manitoba. Partridges were studied in the area from April 1974 to April 1975. Four coveys were monitored on an almost daily basis from October 1974 until mid-March 1975. I recorded location and size of coveys, and the relative proportion of males (birds showing distinct "horseshoes" on the underparts) to females (birds lacking "horseshoes") within each covey. Two partridges, one each from two coveys, were captured in early November in baited cloverleaf traps and marked with ponchos (Pyrah 1970) for individual recognition. The other two coveys were recognized by location within defined home ranges and by the different proportions of males to females within each covey.

Total numbers of birds declined from 43 on 1 October to 23 on 1 March (Table 1). The relative

TABLE 1—Change in numbers of Gray Partridge in each of four coveys, October 1974 to March 1975, Lyleton, Manitoba

	Number of partridges				
	Covey				
Date	1	2	3	4	Total
1 Oct.	11	9	11	12	43
15 Oct.	11	9	11	12	43
1 Nov.	11	8	11	11	41
15 Nov.	11	8	10	11	40
1 Dec.	11	7	10	11	39
15 Dec.	10	7	9	11	37
1 Jan.	10	7	9	11	37
15 Jan.	7	2	6	8	23
1 Feb.	7	2	6	8	23
15 Feb.	7	2	6	8	23
1 Mar.	7	2	6	8	23

proportions of males to females within each covey did not change during the winter; there was no suggestion that one sex suffered greater losses than the other. Each covey lost some members over the winter, but most losses occurred during a severe snow storm in January. The storm, the worst on record in the area since March 1966, continued unabated from noon on 10 January 1975 until noon on 12 January, and covered all of southern Manitoba and southeastern Saskatchewan. Temperatures varied between -16 and -25°C, wind speeds from 55 to 65 km/h, with gusts to 100 km/h, and 16.5 cm of snow fell at Lyleton. The result was a 38% loss in total numbers of partridges, covey 2 being particularly hard hit as its numbers declined from 7 to 2 birds. No further losses were noted for the duration of the winter.

The reduction in numbers was almost certainly a result of the storm, and not of other factors such as emigration (see Jenkins 1961; H. M. Hunt, unpublished), as each covey was found in the same home range before and after the storm. Thus, one storm was responsible for 70% of the total over-winter loss of partridges on the study area.

I thank the Atmospheric Environment Service, Winnipeg, for weather information, R. J. Wang for allowing me to work on his land, H. M. Hunt for allowing me access to his unpublished data, and D. Keppie for his comments on the manuscript. This study was supported by National Research Council grants to R. M. Evans and a University of Manitoba fellowship to myself.

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Further Records of *Ornithodoros* Ticks on Prairie Falcons and in Bat-inhabited Buildings in Canada

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Wilkinson, P. R., R. Fyfe, and J. E. H. Martin. 1980. Further records of *Ornithodoros* ticks on Prairie Falcons and in bat-inhabited buildings in Canada. Canadian Field-Naturalist 94(2): 191–193.

Ornithodoros concanensis and *O. kelleyi* are apparently established in Canada as shown by a second record, and second to sixth records respectively. Their possible contributions to the morbidity of bats, cliff-nesting raptors, and swallows are briefly reviewed.

Key Words: *Ornithodoros concanensis, Ornithodoros kelleyi,* ticks, parasites, bats, falcons, Canada.

Hitherto, the argasid ticks (Acarina: Argasidae) *Ornithodoros concanensis* and *O. kelleyi* have been reported only once each in Canada, the first species incidentally to a survey of Prairie Falcons, *Falco mexicanus* (Oliphant et al. 1976) and the second species as a footnote in Gregson's (1956) monograph. Both records were from Saskatchewan. The further records in Table 1 suggest that these species are established in both Alberta and Saskatchewan, but it is not known whether their life cycles are completed in Canada or whether some instars are introduced annually on migrating hosts.

The following brief literature review suggests that *O. concanensis* should be taken into account as a possible factor in morbidity of cliff-nesting birds, e.g., in studies on the effect of biocides such as organochlo-

TABLE 1—New Canadian records for *Ornithodoros concanensis* and *O. kelleyi*

No. and instar	Sex	Date collected	Place	Host (P = Probable)	Collected or submitted by	Identified by	Lot No.[1]
a) O. concanensis							
50 + *larvae*	—	26 June 1970	Bow R., near Brooks, Alta.	*Falco mexicanus* (around eyes of nestlings)	Fyfe, R.	Clifford, C. M.	CDA 5648 RML 56330
b) O. kelleyi							
1 adult	♀	ca. January 1965	Saskatoon, Sask. (University president's office)	?	Rempel, J.	Gregson and Kohls	CDA 5248
1 adult *2 nymphs*	♀ —	19 August 1965	Waldeck, Sask.	Bats (P) in attic	Taylor, M. E.	Gregson, J. D.	CDA 5389
1 nymph	—	7 February 1974	Lethbridge, Alta. (Galt building)	Bats (P) in attic; Rock Doves present	Weintraub, J.	Clifford, C. M.	—
1 adult	♀	29 March 1978	Dundurn, Sask. (Army camp)	History of bats	Taylor, M. E.	Wilkinson, P. R.	L 91

[1]CDA specimens 5648 and 5248 are in the Canadian National Collection, Biosystematics Research Institute, Canada Agriculture, Ottawa. Specimen L 91 is at the Research Station, Agriculture Canada, Lethbridge, Alberta. RML specimen is at Rocky Mountain Laboratory, United States, Public Health Service, Hamilton, Montana. The location of the other specimen is not known to us.

rine residues in Prairie Falcons and other raptors; similarly *O. kelleyi* should be considered in studies of disease of some bat species.

Ornithodoros concanensis (= *O. aquilae*) is a parasite of bats, raptors, and Cliff Swallows (*Petrochelidon pyrrhonota*); in the USA it is found in or near caves and nests on cliffs (Cook 1972). Webb et al. (1977) stated that the nymphs rest in crevices during the day and locate Cliff Swallow nestlings by sound during the night. Croft and Kingston (1975) considered this tick the most likely vector of the protozoan blood parasite *Babesia moshkovski* to Prairie Falcons. Williams (1947) reported that some nestling raptors were so heavily infested with larvae that their eyes were almost closed, but the birds did not show any other ill effects. In contrast, however, Oliphant et al. (1976) concluded that the death of two nestling Prairie Falcons in Canada was due to "general debilitation brought on by the massive tick infestation." Other species of *Ornithodoros*, or viruses carried by them, have caused nest desertion in Brown Pelicans (*Pelicanus occidentalis*) (King et al. 1977) and abnormalities in sea birds (Bourne et al. 1977). *Ornithodorus concanensis* has been recorded biting a human, in a building (Kohls et al. 1965).

In the USA *O. kelleyi* has been recorded from bats, bat caves, and buildings with actual or past bat infestations (Kohls et al. 1965). Canadian records are from buildings with a history of actual or probable bat habitation.

The involvement of ticks as disease vectors is well known but it should be noted that one host of *O. concanensis* in the USA (and possibly in Canada) is the Cliff Swallow, which may be involved in the cycle of western equine encephalitis virus (Hayes et al. 1977). The bat hosts of *O. kelleyi* (unidentified in Canada) may be involved in the rabies cycle, but the transmission of this disease by ticks is still controversial (Hoogstraal 1966; Vanag and Grokhovskaya 1978).

The two species are apparently established in Canada and should be taken into account in future studies of the host animals mentioned.

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Wolffia columbiana (Lemnaceae), Water-meal, New to Manitoba

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Cody, William J. 1980. *Wolffia columbiana* (Lemnaceae), Water-meal, new to Manitoba. Canadian Field-Naturalist 94(2): 193–194.

Wolffia columbiana is added to the list of vascular plant flora of Manitoba.

Key Words: *Wolffia columbiana*, Lemnaceae, Water-meal, Manitoba, new records, geographical distribution.

Dore (1957) reviewed the occurrence of *Wolffia* in Canada. At that time, two species, *W. columbiana* Karsten (*W. arrhiza sensu* Scoggan (1978)) and *W. borealis* (Engelm.) Landolt and Wildi (*W. punctata* auct. amer. non Griseb.), were known from southern Ontario and southwestern Quebec. A distribution map was given by Dore (1957).

During field work in Riding Mountain National Park, Manitoba, in the summer of 1979, *Wolffia columbiana* (Water-meal) was discovered in association with *Lemna minor* (Duckweed), on the surfaces of six widely separated beaver ponds. Data are as follows:

Manitoba: Riding Mountain National Park, 5 km S of Moon Lake on Highway 10, 50°50.5′N, 100°01′W, *Cody & Wojtas 23719*; Central Trail, 0.5 km W of Baldy Lake Trail junction, 50°51.5′N, 100°34.2′W, *Cody 24510*; Central Trail, 2.8 km W of Baldy Trail junction, 50°51.6′N, 100°36′W, *Cody 24514*; 21 km W on Lake Audy Road from Highway 10, 50°47.2′N, 100°09′W, *Cody 24555*; Baldy Lake Road, 2.7 km S of Central Trail, 50°50.3′N, 100°35′W, *Cody 25342*; Baldy Lake Road, 2.5 km S of Central Trail, 50°50.5′N, 100°34.5′W, *Cody 25355*.

Specimens in FAA (ethyl alcohol, glacial acetic acid, formaldehyde, water mixture) solution in sealed glass ampules as described by Dore (1957) have been placed in the Agriculture Canada herbarium at Ottawa (DAO), and duplicates will be deposited in the herbaria at the University of Manitoba (WIN) and Riding Mountain National Park.

No flowers were seen on the *Wolffia columbiana* material collected at Riding Mountain National Park, and indeed flowers of *Wolffia* have rarely been observed. Dore (1957) stated that none of the Canadian specimens examined by him bore flowers. More recently flowering *Wolffia* was observed in the Ottawa area (Thomson 1970; Hanes 1971). The unisexual flowers were found there in late August, but in Manitoba flowering might occur somewhat earlier.

Landolt and Wildi (1977) give the range of *Wolffia columbiana* as "Nord-, Mittel- und Südamerika — In Nordamerika nordwärts bis Nebraska, Wisconsin und Ontario; westlich der Rocky Mountains nur isoliert in Südkaliforien und Oregon." The eastern North American distribution is better described by Fernald (1950) as "Fla. to La., n. to Mass., sw. Que., N.Y., s.Ont., Mich., Wisc. and Minn." A map of the Great Plains distribution is given by the Great Plains Flora Association (1977). This map shows the northernmost collection in that area in Pembina County, North Dakota, adjacent to the Canadian border. The collections reported in this paper are an extension of the known range some 320 km northwestward from Pembina County, and are the first to be reported from the province of Manitoba. The presence of *Wolffia columbiana* at Riding Mountain National Park indicates that the species should be sought in the area between Riding Mountain and the United States border, and perhaps also in ponds in eastern Saskatchewan.

The question as to whether *Wolffia columbiana* is indigenous or introduced to Riding Mountain National Park remains. Although the plant was very common in six beaver ponds, it was not observed in adjacent beaver ponds (e.g., on the opposite side of the road). The transportation of *Wolffia* fronds on the boats of park visitors might seem plausible if the fronds had been found on the surface of quiet bays of the larger lakes, but this explanation would not seem applicable to beaver ponds that are shallow and full of snags and are thus not conducive to boating. Beaver ponds could, however, receive drainage from boated areas that contain *Wolffia* fronds, or the fronds might be transported naturally by waterfowl or rodents. The distance from sites in North Dakota and Minnesota is sufficiently close that the presence in Riding Mountain National Park could be a natural one.

Illustrations of *Wolffia columbiana* and *W. borealis (sub W. punctata)* may be found in the monograph of Lemnaceae (Daubs 1965) as well as in Dore (1957) and Hanes (1971), and maps of the North American distribution of *W. columbiana* may be found in Daubs (1965).

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Aster Florets in the Diet of a Broad-winged Bush-katydid

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Haber, Erich. 1980. Aster florets in the diet of a Broad-winged Bush-katydid. Canadian Field-Naturalist 94(2):194–195.

Inclusion of both disk and ray florets of the Flat-topped White Aster (*Aster umbellatus*, in the diet of a Broad-winged Bush-katydid (*Scudderia pistillata*) is reported.

Key Words: Broad-winged Bush-katydid, *Scudderia pistillata*, feeding, Flat-topped White Aster, *Aster umbellatus*.

The Broad-winged Bush-katydid, *Scudderia pistillata*, is a fairly common katydid of northeastern North America. It generally frequents shrubbery and tall herbs in the vicinity of peat bogs, lakes, swamps, and along fence rows. Little specific data regarding the feeding habits of this species are available in the literature other than such comments that the species is often found on alders, tall herbs, and grasses (Walker 1904; Blatchley 1920). The following account documents the inclusion of the florets of the Flat-topped White Aster, *Aster umbellatus*, in the diet of the Broad-winged Bush-katydid.

FIGURE 1. Male Broad-winged Bush-katydid feeding on disk florets of a Flat-topped White Aster.

At 16:30 on a warm and sunny day (9 August 1979) I noticed a katydid placidly foraging on the flower heads of a Flat-topped White Aster. The aster, part of a clump about 1.3 m tall, was growing at the eastern end of Borthwick Ridge at the edge of the Mer Bleue peat bog near Ottawa in an area which became shaded late in the afternoon by nearby Red Maples (*Acer rubrum*).

The male katydid, perched on top of the inflorescence, was quite conspicuous although its slow movements and markedly veined tegmina gave it the appearance of a leaf mimic (Figure 1). The katydid continued to feed on the partially shaded flower heads seemingly undisturbed by the frequent flashes while I photographed it from a few centimeters away. During the 20 min of observation, the katydid foraged almost exclusively on the disk florets of two flower heads. Beginning first with the projecting style and anther ring of those florets that were in anthesis, the katydid chewed progressively downward to and as well included the lobes of the tubular corollas. Only those disk florets that were in anthesis were grazed leaving intact the younger, closed florets. While it was feeding on the two flower heads, the katydid ate only a single ligule of a ray floret. The katydid and aster inflorescence were subsequently enclosed within a polyethylene bag and moved inside, next to a laboratory window with the inflorescence axis supported in a beaker of water. The katydid continued to feed occasionally on disk florets for several days before succumbing within its restrictive enclosure.

The katydid's discriminating grazing habit while on the heads of the Flat-topped White Aster may reflect its preference for the protein-rich pollen grains.

I thank J. E. H. Martin of the Biosystematics Research Institute, Agriculture Canada for identifying the katydid.

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Bark of Pine Galls Eaten by Red Squirrels

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Salt, Jim R. and Carol A. Roth. 1980. Bark of pine galls eaten by Red Squirrels. Canadian Field-Naturalist 94(2): 196.

The bark and resinous excretion on pine galls, caused probably by Western Gall Rust, *Endocronartium harknessii,* was eaten by Red Squirrels (*Tamiasciurus hudsonicus*), after the galls had been cut from small branches of Lodgepole Pine (*Pinus contorta*) and Jack Pine (*P. banksiana*). The feeding habit, observed in spring, was localized in Rocky Mountain and central Alberta localities.

Key Words: diet, Red Squirrel, *Tamiasciurus hudsonicus,* feeding habit, *Pinus.*

During ecological studies in the Rocky Mountains of Alberta and British Columbia over a number of years, we have occasionally encountered concentrations of galls from conifers, snipped and peeled completely of bark, lying beneath the trees in localized areas of 0.15 ha to more than 2 ha. It seemed reasonable to attribute the snipping and de-barking to Red Squirrels, *Tamiasciurus hudsonicus*, but we had no proof of such activity. Between 5 and 15 April 1978, however, we found extensive debris of these galls under Lodgepole Pine, *Pinus contorta*, in the Jasper and Yellowhead Pass regions, and at two sites we observed Red Squirrels cutting and feeding on them.

Two species of pine have been found to provide this food, Lodgepole Pine in the Rocky Mountains and Jack Pine (*P. banksiana*) in central and north-central regions of Alberta. George Evans (University of Alberta, Department of Entomology, personal communication) examined specimens of the galls and suggested that they were probably a result of Western Gall Rust, *Endocronartium harknessii.*

Although the many notes on Red Squirrel foods agree that the species is omnivorous and opportunistic in its feeding — even taking some toxic fungi — none except that of A. W. F. Banfield (1974. The mammals of Canada. University of Toronto Press, Toronto. 438 pp.) mentions bark as a significant food item, and none has recorded the cutting of galls from conifers. James L. Mielke (1956. The rust fungus, *Cronartium stalactiforme*, in Lodgepole Pine. Journal of Forestry 54: 518–521), writing on a related rust, notes that various rodents feed on the trunk-bark of infected trees. Mielke has noted both tree squirrels and the Porcupine, *Erethizon dorsatum*, in this regard, but adds that the mammals rarely strip the entire area infected. Mielke is of the opinion that the rust itself is the food attracting the rodents in such cases. In our experience with gall-forming infections, however, the proportion of fungus taken appears very small, and the bark and excretions of resin seem a more likely food.

The galls are solid, 1 cm to > 3 cm in diameter, and are never cut into; they are not found in squirrel middens nor in food-stores. They are snipped, peeled completely, and dropped. The bark for a few centimeters on either side of the gall may also be taken; cones, often attached to the snipped twig or gall, are never eaten. We have no evidence that they are taken by Porcupines, although in some study areas this species has been noted high in pines, feeding on the bark of the upper trunks.

As many as 20 galls may be found beneath a single tree, although 5 to 7 is probably average. We have recorded several hundred galls in an area of less than 1 ha (Jasper vicinity, 1978). As Mielke (*loc. cit.*) also notes, there seems to be a seasonal pattern to this feeding, for our records are concentrated in the spring, from late March to late May.

We are much indebted to W. G. Evans for examining specimens of the galls, and for research in the literature on rust fungi.

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Appropriation of an American Robin Nest by Dark-eyed Juncos

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Butler, Robert W. 1980. Appropriation of an American Robin nest by Dark-eyed Juncos. Canadian Field-Naturalist 94(2): 197.

A pair of Dark-eyed Juncos (*Junco hyemalis oreganus*) nested in an abandoned American Robin (*Turdus migratorius*) nest.

Key Words: Dark-eyed Junco, American Robin, nest appropriation.

Nest reuse is widespread among birds (e.g., Ervin 1977; Favaloro 1942; Roberts 1955). Few quantitative data, however, exist on the time between the abandonment of a nest by one species and its reuse by another species.

On about 18 April 1979 a pair of American Robins (*Turdus migratorius*) began building a nest at the junction of three beams that supported the roof of a covered walkway on the campus of Simon Fraser University, Burnaby, British Columbia. Strong winds destroyed the nest before it was finished, but it was rebuilt and by 23 April a female robin was sitting in the nest. No eggs were laid and the nest was abandoned by 1 May. On 25 May a pair of Dark-eyed Juncos (*Junco hyemalis oreganus*) were relining the nest with fine grasses and hair. This date is within the nesting period of local Dark-eyed Junco populations (Campbell et al. 1972; personal observation). The juncos laid four eggs, which hatched on 15 or 16 June, and the four nestlings fledged about 30 June.

On 3 July the nest was removed, photographed, and dismantled. The outer shell of the nest tilted forward and measured 10.5 cm high at the front and 11.0 cm at the rear. Entirely built by the robins, it was composed of grasses, plant stems, wire and string held together by mud. The inner cup was 9.0 cm in diameter and from 1.0 to 4.5 cm deep. Coarse grasses lined the bottom and sides of the mud cup upon which was laid a layer of fine grasses and hair. The layer of coarse grasses and hair was 3.0 cm deep.

It was difficult to differentiate between the nest materials placed by the robins and those contributed by the juncos. I presume that the entire layer of fine grasses and hair was placed by the juncos, because they were seen lining the nest with them. The remainder of the nest, including the layer of coarse grasses, was probably built by the robins, because it was similar to other robin nests in the vicinity. The entire nest's dry weight was 250.0 g, of which the fine grasses and hair placed by the juncos weighed 12.4 g (5.0%).

The subspecies *J. h. hyemalis* nests on verandahs on rare occasions (Godfrey 1966). A Dark-eyed Junco was incubating a three-egg clutch in a new nest under the same covered walkway, about 4 m from the location of the abandoned robin nest, on 15 July. None of the juncos were marked but I presume that the same pair that used the abandoned robin nest also used this second nest. This new nest was entirely built by the juncos and weighed 38.5 g. It was composed of coarse grasses, small pieces of leaves and moss, and lined with fine grasses and hair.

I thank R. C. Long and an anonymous referee for their comments on this manuscript.

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Nest-tree Selection by Red Squirrels in a Boreal Forest

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Fancy, Steven G. 1980. Nest-tree selection by Red Squirrels in a boreal forest. Canadian Field-Naturalist 94(2): 198.

Tree diameter and branching structure appear to be the most important factors influencing nest-tree selection by Red Squirrels (*Tamiasciurus hudsonicus*) in the boreal forest.

Key Words: Red Squirrel, *Tamiasciurus hudsonicus*, nest-trees, nests, boreal forest.

Red Squirrels (*Tamiasciurus hudsonicus*) of both sexes use nests for resting and sleeping at all times of the year, and for the birth and rearing of the young by the female. Natural cavities in trees are the preferred nesting location where available (Hamilton 1939; Layne 1954). These cavities, however, are uncommon in coniferous forests, where underground nests and outside tree nests, constructed primarily of grass or moss with an inner chamber of shredded bark, leaves, feathers, and fur, are commonly utilized. As many as nine spherical tree nests have been found in a squirrel's territory (Fancy 1979).

The purpose of this note is to document the characteristics of nest-trees selected by Red Squirrels in the northern boreal forest. Data on 112 nest-trees were collected as part of a larger study on Red Squirrel ecology conducted near Atlin, British Columbia (59°38'N, 133°19'W) (Fancy 1979). Although White Spruce (*Picea glauca*) comprised only 41% of the basal area of coniferous species on the study area, 90% of the nests were in this species. Six percent of the nest trees were found in Lodgepole Pine (*Pinus contorta*), and 4% were found in Subalpine Fir (*Abies lasiocarpa*). Lodgepole Pine and Subalpine Fir made up 55% and 4% respectively, of the total basal area of coniferous species.

Tree diameter and branching structure appear to be the most important factors influencing nest-tree selection. The mean diameter at breast height (dbh) of 28.2 cm for the 101 White Spruce nest-trees was significantly greater than the mean dbh of 18.2 cm for 101 randomly selected White Spruce trees (t-test, $P < 0.001$). Based on qualitative observations, the branch density of White Spruce nest-trees was less than that of smaller-diameter White Spruce trees, which indicated that the height and crown size of the tree was more important than branch density within this species. White Spruce was consistently chosen for nest locations over larger-diameter Lodgepole Pine and Subalpine Fir, which have a less dense branching structure than does White Spruce. In seven territories where Lodgepole Pine or Subalpine Fir were the only species, nests were always located in the part of the tree with dense branches.

Eighty-five percent of the nest-trees had their crowns interlocked with at least one other tree, and 96% had their branches less than 1.5 m from the branches of a neighboring tree. The height of nests above the ground ranged from 2 to 14 m; 69% of the nests, however, were located between 5 and 8 m above the ground. There was no significant difference (analysis of variance, $P > 0.05$) in nest height between the three tree species.

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A TRIBUTE TO WILLIAM AUSTIN SQUIRES, 1905–1978

It was typical of Austin Squires that his last public appearance had to do with an act of great generosity. Not so typical was the response it engendered. In a rare ceremony at Fredericton in November 1978, and then in failing health, he presented his manuscript of a history of the city to the civic authorities for the benefit of all the citizens. He was then created a Freeman of Fredericton in recognition of "... outstanding contributions to the City, to New Brunswick and to Canada, in his roles as naturalist, historian, museologist and author." A month later, on 12 December, the kindly benefactor was dead at age 73, after a lifetime of service and accomplishment.

Fredericton: the first three hundred years by W. A. Squires, will appear on the bookstands as one of the earliest of the capital city's observations of the bicentennial of New Brunswick (1784–1984), and as a major gift to the literature of a province. It will stand as well, in a very fitting manner, as a memorial to one of the outstanding interpreters of the mysteries of natural and human history.

William Austin Squires was born in the family home at Fredericton on 6 September 1905. He received his early education in local schools, matriculating in 1923. His inherent curiosity about wild things and obvious love for nature were revealed when he was a young boy. What was to become a lifelong interest in the study of birds began in grade 4, when he began a written record of his observations of spring migrants. In 1927 he graduated from the University of New Brunswick (U.N.B.) with a B.A. degree, with honors in natural science and chemistry, the preceding year having been awarded the Noel Stone Memorial Scholarship for highest standing in those subjects. He continued his education in the fields of zoology, entomology, and botany at Ohio State University, receiving his M.Sc. degree in 1929. His thesis was on the bronze cutworm of New Brunswick's Tantramar marshes. The Depression cut short his doctoral program at that institution.

He began his professional life as a teacher. From 1930 he instructed in provincial public schools, resigning in 1939 as vice-principal of Minto-Newcastle Creek Consolidated School. For the major part of his career, the next 30 years, he was Curator of Natural Science at The New Brunswick Museum, in Saint John. During most of that time he was secretary of the board and of the executive committee of the museum. In the last year before his retirement he also served as Chief Curator. Those three decades witnessed a modernization of museum plant and interpretive technology, a significant expansion in its holdings, and a five-fold increase in visitor use, developments in which Austin Squires played a major role. But for him there was to be no life of confinement at the museum. He was an athletic man who loved the outdoors, and he travelled extensively on foot and by ski and canoe in the remoter parts of New Brunswick, his earlier explorations being undertaken before the great forest and mineral resources of the interior of the province were opened up for exploitation. His observations of wild life led to a fine appreciation that in nature there is a place for everything, long before ecology and environment became household words. He built a solid reputation as a field ornithologist in the tradition of Montague Chamberlain and William Moore. During his travels he collected many thousands of specimens for the museum herbarium, contributing immensely to the knowledge of plant distribution in the province. Through dedication and unflagging interest in his work, he became one of the most complete natural scientists New Brunswick has produced.

Austin Squires wrote over 90 articles and several books, many of them about the fauna and flora of his beloved native province. His career as an author began during his student days at U.N.B., his first published compositions in *The Brunswickan* covering topics such as "The economic value of hawks and owls," "Music in autumn," and "Blessings and plagues of wild life." The broad spectrum of his continuing professional interest in natural history, and the developing appeal of historical research as a hobby, are illustrated by his frequent contributions over 40 years to journals such as *The Educational Review, The Atlantic Advocate,* and *The Canadian Field-Naturalist.* For example, in their columns he reported the occurrence in New Brunswick of the Wood Thrush and *Impatiens roylei,* discussed the great sagamore of the Maliseets, and considered currency in the Atlantic Provinces before Confederation. From 1950 to 1969 he authored 112 issues of *Nature News,* in which he reported his own observations of nature and those of others. That remarkable series of modest pamphlets provided the catalyst for the awakening in New Brunswick of a wide public interest in the study of nature, which saw the birth in the early 1960s of naturalists' organizations in Fredericton, Saint John, and Moncton and later at several other centers. Those naturalists were in the vanguard of the environmental movement then gathering momentum.

Austin Squires' *The birds of New Brunswick,* first published in 1952, followed by a revised edition in 1976, is an indispensable companion for the student of provincial ornithology. *The mammals of New Brunswick* became available in 1968 and a delightful volume, *A naturalist in New Brunswick,* in 1972. His

W. Austin Squires

Photograph taken by Harvey Studios Limited, Saint John, New Brunswick in 1968.

first book-length work in the field of historical writing was *The 104th Regiment of Foot, the New Brunswick Regiment,* which was published in 1963 and for which he received a special award of the American Association of State and Local History. His distinguished literary record belies his assertion that, as an undergraduate, he barely passed in English. It is, rather, a testimonial to the reality that he wrote, as the university orator commented when presenting him for an honorary LL.D. degree at his Fredericton alma mater in 1964, "... with an English limpid in style, acute in observation and appealing by its inherent interest."

Many honors and special appointments, too numerous to cite fully, marked his career as a natural scientist and museologist. When the Canadian Museums Association was formed in 1947 he was elected to the founding council and served three terms. In 1948 he was named a member of the Canadian National Committee for the International Council of Museums under UNESCO, serving until 1960. He was elected a member of the American Ornithologists' Union in 1950. His appointment as a member of the Laboratory of Ornithology of Cornell University was a particular source of pride to him. He was chairman of the New Brunswick Historic Sites Advisory Board from 1955 to 1960. The Ottawa Field-Naturalists' Club named him an honorary member in 1972, in which year he was also president of the Fredericton Field Naturalists' Club. In 1973 he was named the first honorary member of the New Brunswick Federation of Naturalists. Retirement in 1969 did not end his long association with The New Brunswick Museum, which he continued to serve in the capacity of Curator Emeritus, President, and Honorary Trustee.

During the 30 years he worked at the Museum, he maintained his home at Fredericton, commuting some 70 miles back and forth on weekends. (He claimed that most of the ideas for his articles and books were born and marshalled on the lonely highway between Saint John and Fredericton.) Despite long absences from home, Austin Squires was a devoted family man. His wife Helen is an amateur ornithologist and expert botanist in her own right. With her, and their four children, all of whom survive him, he shared his outdoors experiences and enthusiasm for nature study. He was essentially a modest and retiring man, but on those precious weekends with his family he still found time for courteous reception of visitors, young and old, to identify specimens whether animal or vegetable, to advise and to encourage. With his wife, he enjoyed gardening. Their property, long since engulfed by urban development, remains a quiet haven of tall shade trees and tenderly cared-for flower beds.

Consummate naturalist, scholar, gentle New Brunswicker, Austin Squires enriched the life of many. He is sorely missed by those privileged to have known him.

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News and Comments

International Seminar on Energy Conservation

"Energy Conservation and the Use of Solar and Other Renewable Energies in Agriculture, Horticulture, and Fishculture"

This international seminar will be held at The Polytechnic of Central London from 15 to 19 September 1980. The seminar's emphasis will be on practical measures and applications in depth and their effectiveness within an environment. The proceedings will be published by Pergamon Press.

The energy conservation section will be concerned with the reduction of energy inputs in the production, processing, and marketing of food and feeds. It will include the structure, construction, and design of buildings such as livestock housing, greenhouses, fish tanks, and their housing, and allied subjects which have a bearing, directly or indirectly, on activities in the bio-industries. Systems combining conservation with new husbandry techniques and renewable energies will also be covered.

Other sections will deal with all aspects of the current and future use of non-fossil fuels in agriculture, horticulture, and fishculture. As with conservation, papers will cover the production, processing, and marketing of food and feeds in the broadest sense, such as storage, the use of waste heat from industrial and nuclear processes, mixed energy source systems, multi-husbandry technique applications, system controls, and computer work.

For details, including information on the submission of papers, write to: Frederick Vogt, The Polytechnic of Central London, 35 Marylebone Road, London NW1 5LS. Phone (01) 486 5811 Ext. 284.

Polar Bear Pass and Land Use Management

Polar Bear Pass is the first ecological site of the 151 proposed by the Canadian Committee of the International Biological Programme (CC-IBP) for north of 60°N for which public consultations on the land use management have begun. Situated on Bathurst Island, Northwest Territories, 150 km NW of Resolute, Polar Bear Pass nurtures one of the largest concentrations of birds and mammals in the High Arctic. Each summer Polar Bears cross the island westward from Goodsir Inlet to Bracebridge Inlet through the fertile core of the site, the lowland pass; hence its name. Four important Thule archeological sites and pre-Dorset tentremains (possibly 4000 yr old) lie within the proposed 2634-km^2 site.

Since 1968, the National Museum of Natural Sciences has operated a research station at Polar Bear Pass to study the life histories and behavioral adaptations of arctic animals.

Although Inuit land claims there have not yet been settled, Inuit Tapirisat of Canada, the negotiating body, has agreed that the future of the area should be the subject of public discussions, particularly by residents of the High Arctic.

The chairman of the interdepartmental Working Group on Proposed IBP Ecological Sites says, "We hope that northern residents, the oil and gas and mining industries, scientists, conservation groups and anyone else who has an interest in the area will come forward with their views and suggestions for the development of a management plan to ensure the maintenance of the ecological values of Polar Bear Pass."

Saw-whet Owls Hatched in Captivity

In 1979 four Saw-whet Owls, *Aegolius acadicus*, were hatched at The Owl Rehabilitation Research Foundation (operated by Larry and Katherine McKeever, R.R. 1, Vineland Station, Ontario L0R 2E0) by damaged but previously wild parents. The first owlet hatched about 30 June and fledged 21 July. The last owlet fledged 30 July. At fledging the color of the owlet irises was pale turquoise-gray although a month later it changed to a neutral beige-yellow. The hatching of these owlets is apparently a unique event. All four will be overwintered on live rodents and released in suitable habitat in the spring.

Colonial Waterbird Group Fourth Annual Meeting — Announcement and Call for Papers

The fourth annual meeting of the Colonial Waterbird Group, co-sponsored by the Colonial Waterbird Group and the Canadian Wildlife Service, will be held 9-12 October 1980 in Ottawa, Ontario, Canada. A symposium on the effects of humans on colonial birds is planned, and a proceedings will be published. Anyone wishing to contribute to the symposium should send an abstract to J. Burger (*Department of Biology, Livingston College, Rutgers University, New Brunswick, New Jersey 08903*) by 1 August 1980. For information on contributing papers, please also contact J. Burger, and note that abstracts must be received by 1 September 1980. For information on registration, please contact *R. Michael Erwin, Migratory Bird and Habitat Research Laboratories, U.S. Fish and Wildlife Service, Laurel, Maryland 20811.*

World Wildlife Fund (Canada) Arctic Grants

World Wildlife Fund (Canada), WWF (Can), invites applications for funding of projects in the Canadian Arctic, where 'Arctic' refers to all land and water north of the tree line, and 'wildlife' includes wild plants, animals, and habitats. All projects will be rated on their scientific excellence by the Scientific Advisory Committee of WWF (Can) and must lead clearly to the *conservation* or *protection* of species or habitats. *Socio-economic* aspects of species/habitat conservation will be eligible for support. Research or action should if possible, have broad applicability to other areas, countries, or species.

Grants may be awarded for one-, two- or three-year periods. Graduate students in Canadian universities may apply through their supervisors. Funding will be considered for both minor (less than $10 000), and major projects.

Deadlines for all major projects are 15 May 1980 and 31 October 1980. Minor projects will be considered immediately. For application forms write to: Mr. Monte Hummel, Executive Director, World Wildlife Fund (Canada), 60 St. Clair Avenue East, Suite 201, Toronto, Ontario M4T 1N5 or telephone (416) 923-8173.

COPY EDITOR NEEDED

The Canadian Field-Naturalist requires a Copy Editor to start work in June 1980 on the 1981 issues. The position involves the preparing of manuscripts and other copy for the printer and the correcting of the galleyproofs. Competency in the English language and an ability to pay attention to details are essential. The Copy Editor corrects grammar, punctuation, spelling, and wording and ensures that the material conforms to the journal's style. Although this task is a volunteer one, there is an honorarium. Anyone potentially interested in carrying out these duties should contact the Editor Dr. Lorraine C. Smith, R.R. 3, Stittsville, Ontario K0A 3G0; home telephone 836-1460, office telephone 996-5840.

Book Reviews

ZOOLOGY

Analysis of Vertebrate Populations

By Graeme Caughley. 1977. John Wiley and Sons, New York. 234 pp., illus. U.S. $19.95.

"I have selected from the literature those analyses and those ways of approaching a problem that I think are immediately relevant," stated Caughley in his introduction to *Analysis of Vertebrate Populations*. "Because many readers will not be at ease with calculus and matrix algebra these powerful techniques are not used, the only expertise assumed in the reader being a knowledge of elementary algebra and statistics."

Analysis of Vertebrate Populations deals with the statistical procedures designed to interpret terrestrial animal populations. The topics covered deal with all aspects of population analysis and include age, abundance, rate of increase, fecundity, and mortality. As a concluding chapter, Caughley has added a section on population analysis in management.

The entire text of *Analysis of Vertebrate Populations* is wildlife-oriented. The author illustrates the use of the various statistical procedures contained, with "real" wildlife population data. In so doing, there are numerous occasions where the philosophies of wildlife management are also included. This blend of wildlife management philosophy and wildlife population analysis greatly contributes to the book's unique character.

Chapter 11 deals with the philosophy of wildlife management and boils management down to its fundamental issues. "There are, in fact, only three problems of population management: (1) the treatment of a small or declining population to raise its density, (2) the exploitation of a population to take from it a sustained yield, and (3) the treatment of a population that is too dense, or which has an unacceptable high rate of increase, to stabilize or to reduce its density." As Caughley points out, the largest percentage of wildlife management effort is spent in trying to determine whether a problem exists and if so whether "it can be solved by harvesting, conservation or control."

There are two points in the text that could have been stressed more strongly. First, "population analysis is concerned with the numerical attributes of a population" and therefore it is critical that the analyst understand all the intricate components of the environment that affect the population being studied. Second, "occasionally the best management may be no management at all."

Analysis of Vertebrate Populations is an excellent book. It does not contain all the answers nor all the methods for analyzing wildlife populations, but it does include all the basics.

PETER CROSKERY

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A Field Guide to the Seabirds of Britain and the World

By G. S. Tuck and H. Heinzel. 1978. Collins, London. 292 + xxviii pp., 48 pp. color plates, 312 maps. £5.25.

It is often forgotten that Roger Tory Peterson's *A field guide to the birds*, which first came out in 1934, was not the first of the pocket field guides. Precedence goes to W. B. Alexander's *Birds of the ocean*, first published in 1928. For a long time this was the only book to cover this specialized topic. It has been partially replaced by the Smithsonian seabird identification manuals, Harrison's almost unobtainable *Seabirds of the South Pacific* and most recently by George Watson's excellent *Birds of the Antarctic and sub-Antarctic*. But there has been a need for a new guide to cover all the seabirds of the world.

Tuck and Heinzel's book appears, appropriately enough, just 50 years after Alexander's. Captain Tuck is Chairman/Editor of the Royal Naval Bird-watching Society, and his text is written with interested amateurs in mind; only professional seamen and oceanographers are likely to see most of the species he describes. He covers the primary seabirds — penguins, tubenoses, pelecaniforms, phalaropes, sheathbills, and larids, or "those for which the sea is the normal habitat and principal source of food." (One might quibble that in these terms eiders and steamer-ducks have a better claim to inclusion than many freshwater terns and pelicans, but I can't think of a better definition.) The field characteristics and distributions of each species are described clearly, at something over Petersonian length, and the Introduction

gives a brief general account of the various seabird groups, their principal foods, and the oceanographic factors that determine their distributions at sea. A short reference list for further reading might have been a useful addition.

Hermann Heinzel's color plates and line drawings cover all but the rarest species, as well as several of the better-marked subspecies. Any field guide stands or falls by its illustrations, and these are not very satisfactory. Heinzel's flying birds are not very good, and his storm-petrels are particularly unconvincing. There is an overemphasis on characters which are more apparent in the museum than at sea: no Sabine's Gull ever had the exaggerated tern-like tail of the bird in Plate 39. The flying storm-petrels in Plate 13 all have their wings set at very similar, stylized angles, which makes them seem more alike than they really are. Identification by tail-forks, divided rump-patches, leg length, and foot color is recommended; yet one of the best ways to tell Wilson's Storm-Petrel from Leach's is by the flat way it holds its wings, as the line drawing on p. 45 shows. Heinzel also tends to draw the beaks too long, sometimes grotesquely so. This is not just an artistic criticism; beak size and shape can be useful identification characters. Thus the shortish, rather spiky beak of the Arctic Tern comes out in Plate 42 as something the length and shape of a Common Tern's, while the Common Tern's beak is longer still. (As a further complication there is no mention, in illustration or text, of how the two can be separated by their under-primary patterns.) On the positive side, Heinzel rightly shows his penguins in the water as well as on land; given the zoo image of a little man in a tuxedo, it is hard to realize just how little one can see of a swimming penguin. Three final points: the Masked Booby's black tail is not always as obvious as shown; I would have liked an illustration of the confusing juvenile Peruvian and Blue-footed Boobies; the line drawing of immature Frigate-birds (p. 83) has no identifying captions.

The third section of the book gives world distribution maps, prepared by Crispin Fisher. These, unfortunately, contain many errors. Canadian readers will be surprised to see that we have only one Gannet colony, and that Fulmars do not breed north of Davis Strait, despite evidence to the contrary which the cartographer's father, the late James Fisher, published over a quarter of a century ago! Finally John Parslow summarizes seabird breeding distributions in Britain and Ireland; I understand that this will be replaced by the appropriate local information in a series of planned regional editions of the field guide.

All field guides are imperfect and every birdwatcher feels himself uniquely qualified to point out their imperfections. This review is no exception. Nonetheless I feel that Tuck and Heinzel have produced a very useful book which will receive a great deal of use from interested observers. What I need now is an oceanographic cruise to somewhere exotic so that I can use it myself.

R. G. B. BROWN

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Wolf Ecology and Prey Relationships on Isle Royale

By Rolf Olin Peterson. 1977. United States Department of the Interior, National Park Service, Monograph Number 11. Superintendent of Documents, United States Government Printing Office, Washington, D.C. 20402. 210 pp. US $5.95.

Since 1958, a series of graduate students from Purdue University have conducted a long-term study to examine the role of wolves as predators on Moose at Isle Royale National Park, Michigan. The present monograph presents data collected by one student during a four-year period of the study, from 1970 to 1974. During this study period, several significant changes in the predator-prey system were observed. These new trends in Moose-wolf relations set the stage for the final publication of the entire 20-year study.

The Isle Royale wolf population fluctuated since the last published account of the study (Wolfe, M. L. and D. L. Allen. 1973. Continued studies of the status, socialization and relationships of Isle Royale wolves. Journal of Mammalogy 54: 611–636). Wolf numbers have increased because of a recent abundant food supply. As a result of the growth of the wolf population, Peterson recorded an expansion of past territories and the establishment of new territorial boundaries. The recovery of a dead wolf, apparently killed by members of an adjoining pack, is good evidence to indicate intraspecific defense of new territorial boundaries.

The summer diet of wolves on Isle Royale has also changed. Beaver, when available, now contribute much more to the diet of wolves than previous Isle Royale studies indicated.

Peterson also includes a discussion of wolf behavior based mainly on observations made at the Brookfield

Zoo in Michigan. Behavioural observations on captive wolves are presented because field sightings were rare, therefore making detailed discussion not possible. This section is interesting, but the information presented has been reported in numerous earlier publications.

Peterson concludes that during his study, Moose were the main food of wolves on Isle Royale. Aerial census combined with direct ground observation indicate that Moose are now abundant relative to the food supply available to them. Using this population data, Peterson offers interesting discussion on the direct (wolf-caused) and indirect (disease-, parasite-, and malnutrition-caused) mortality factors presently affecting the Isle Royale Moose population.

The effect of wolf predation on ungulate prey populations is a popular and controversial topic among biologists, conservationists, and politicians. The Isle Royale situation offers a unique setting in which a single predator-prey system can be examined within a confined area. Peterson's study shows that wolf predation can exert a strong mortality factor operating on the Moose herd; however, the degree of this control is determined by environmental influences, principally prey food supply. Moreover, on Isle Royale it appears that there is a feedback system controlling the level of both populations; this system ensures the survival of both species. Data from this study lead one to believe that there will be wolves and Moose on Isle Royale for many years to come, if no major environmental changes occur.

This monograph is essentially an edited edition of Peterson's doctoral dissertation. The work presents much data in a well written, clear, concise manner. I have only minor criticisms; first, the Methods section could be improved if less divided, and secondly, an occasional figure is unclear (i.e., Figure 106). Also, although the photographs are for the most part useful, they number in excess.

This study is very important because it is part of the only long-term wolf-prey project in North America. I strongly recommend this monograph to wildlife biologists, naturalists, or interested conservationists, and eagerly await the publication of the complete 20-year study.

ALAN J. KENNEDY

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The Mammals of the Palaearctic Region — a taxonomic review

By G. B. Corbet. 1978. British Museum (Natural History), London and Cornell University Press, Ithaca. 314 pp., illus. U.S. $38.50.

The first list of mammals of the Palaearctic Region appeared in 1951 with Ellerman's and Morrison-Scott's *Checklist of Palaearctic and Indian Mammals.* Their work summarized the taxonomic literature from 1758 to 1946 and provided an important foundation for further taxonomic work.

The aims of Corbet's book are two: first, to provide the non-specialist with an independent list of Palaearctic mammals, along with keys for their identification, concise distribution maps, and some taxonomic detail that allows the user to interpret intelligently the results of taxonomic work; and second, to provide the practicing taxonomist with a supplement to Ellerman's and Morrison-Scott's checklist, but limited to the Palaearctic Region. The review, which takes into account the taxonomic literature to 1972 and less fully to 1976, covers 550 species, of which 460 occur wholly or extensively in the Palaearctic Region, the balance being made up of introduced, extinct, or marginal species. The Cetacea are not considered. All species are listed by their scientific names and, in most cases, English common names, followed by a short list of synonyms. Discussions include a brief description of the species' range, which is also shown on a map in the back of the book, and a brief "Remarks" section with systematic comments. These comments serve as an indication of the degree of certainty or uncertainty surrounding the taxonomic conclusions.

Excluding the marine pinnipeds and the Sea Otter, there are 24 Holarctic species listed, two insectivores, two lagomorphs, nine carnivores, and five artiodactyls. The status of a few of these would be regarded as decidedly uncertain by many North American mammalogists (e.g., *Felis lynx* = *F. canadensis; Lepus timidus* = *L. arcticus*) because of lack of conclusive evidence. Corbet has succeeded in distilling a mass of information into a modest-sized book that would be a valuable addition to the book shelf of the practicing taxonomist and a useful reference for the non-specialist. Unfortunately, the price does not match the size of the book, and will no doubt limit its dispersal.

C. G. VAN ZYLL DE JONG

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BOTANY

Genera of the Eastern Plants

By Wade T. Batson. Third edition. Wiley, Rexdale, Ontario. 203 pp., illus. $9.95.

Subtitled, "A guide to the genera of native and commonly introduced ferns and seed plants of eastern North America from the Atlantic to the Great Plains, from Key West — southern Texas to the Arctic," the book is just that. It is a small book, 11.5 cm x 20 cm and little more than 1 cm thick, but it is crammed with information. With it, anyone having only moderate botanical ability should be able to identify to genus any vascular plant growing in the eastern half of this continent. The first seven pages contain a justification for a guide which stops at the generic level, the procedure for using this book, labelled diagrams showing some important details about structures and arrangements of leaves, inflorescences and flowers, a list of the abbreviations used in the book, and a glossary of terms. Then come the keys, descriptions, and illustrations. At the back is a page on poisonous plants, keys to leafless woody twigs, and the index.

Keys are dichotomous and are of the yoked or indented kind. They are brief and, in general, utilize sharply contrasting features which usually can be distinguished quite easily on average specimens. In the first key, the 'Key to major groups of vascular plants,' the Pteridophyta and Spermatophyta are separated by the former's lacking flowers and seeds but reproducing by spores, and the latter's bearing seeds. Within the Pteridophyta, the Gymnospermae, and the monocots of Spermatophyta, the sequence of keying is to orders, to families, and to genera. The dicots, however, are keyed directly to families and then to genera, except the grasses which go through subfamilies and tribes to genera. The arrangement of families follows the sequence used in most modern floras and herbaria, but genera are alphabetic within families. Allowance has been provided in some of the keys for easy-to-make errors of interpretation by inclusion of a family or genus in two or more parts of the key. With each generic name is given the author of that name, then one or more common names, botanical synonyms, the general habit, habitat and range of the plant or plant group, and a number to indicate how many species are in that genus.

The book is profusely illustrated with tiny (6 mm to 18 mm with some to 30 mm high) black-and-white line drawings of one or more species representative of each genus. An individual page may have as many as 35 to 50 individual drawings. The illustrations occupy the right two-thirds of each page with the generic names and descriptions occupying the left two-thirds. The middle third, where illustrations and printing are superimposed on each other, is a unique space-saver. Both are legible and neither detracts seriously from the other. Although these illustrations seem very small at first glance, the user will soon appreciate their usefulness. Good diagnostic features were chosen for illustration and the artist presented them with the clarity of simpleness and sharp lines.

The book appears to have been printed by photographic reduction directly from the typewritten pages of the manuscript. Only the left margin is justified. Errors are few. Perhaps the most important error is on the title page! the printed metric scale, purportedly representing "1 Decimeter — 10 Centimeters — 100 Millimeters" measures only 45 mm! After the original scale was photographically reduced along with the rest of the title page, it seems that the printer forgot to replace it with a life-sized one! Other errors of significance: on page 3 the illustration accompanying the term 'cyme' is clearly of a corymb although the definitions of the two terms in the glossary are correct as far as they go; all citations of the leguminous genus *Abrus* Adans., called Crab's Eye here but more widely known as Rosary Pea because of its attractive black and red but deadly poisonous seeds, are misspelled "Arbus" in the generic entry, page 101, in the list of poisonous plants, page 181, and in the index, page 186, and the authority is incorrectly given as "L." Although "Composite" is consistently misspelled "Composit," this and other similar typographical errors do not seriously detract from the value of this guide.

Canadians east of Manitoba will find this small book a handy, easy-to-use field guide, providing they are satisfied with identification to the genus level only. Western Canadians will also find it useful although the farther west they are the fewer of their genera will be included. It should also prove of particular value to anyone travelling through the southeastern states and wanting to gain a general acquaintance with the flora. Of special assistance in this regard are keys in some of the families, i.e., Ferns and Orchids, which make their first division on a geographic basis: genera of wide distribution vs. genera of southern Florida. This book has the potential of helping a great many people gain a more intimate acquaintance with the individual genera in their flora and, with this comes a deeper appreciation of the whole of their environment.

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A Guide to the Literature on the Herbaceous Vascular Flora of Ontario 1978

By James L. Hodgins. 1979. ("1978"). Botany Press, Toronto. 73 pp. $4 .00.

The most significant part of this collection of bibliographies is found on pages 51–66, a bibliography of regional and local botanical surveys and plant lists for Ontario, concentrating on those published since 1930. Many of these studies were published in limited numbers, if at all, by naturalists' clubs, conservation authorities, and consulting firms, and were distributed to few if any libraries. Such works are often overlooked by indexers of botanical literature, and remain unknown to later researchers. Consequently, Canadian botanists have expressed concern about unnecessary duplication of collecting and expenses in such surveys, and about too little utilization of the results. Here there are 140 botanical surveys listed by author and by county or regional municipality. There are some surprising omissions, such as the Federation of Ontario Naturalists' *Check-list of vascular plants of the Bruce Peninsula* and all of the floristic studies of the Mer Bleue and the Central Research Forest in the Ottawa-Carleton Region. All of the bibliographies in this compilation appear to reflect inadequate consultation of botanists and naturalists outside Toronto. Nevertheless, enough sources of information on the Ontario flora have been listed for this reference to be of considerable value to phytogeographers and conservationists, and it should do much toward alleviating the concerns noted above.

There is also a bibliography of publications, mostly taxonomic monographs and studies of plant distribution in Canada, for genera of native herbaceous angiosperms, graminoids excluded. Coverage is somewhat erratic, and I repeatedly wonder why one paper should be left out while another is listed; however, the number of entries is sufficient to contribute significantly to its objective, that of guiding those with limited experience in plant taxonomy to much of the recent literature useful for plant identification. Some publications as recent as 1979 are included. If this bibliography leads authors of plant lists toward less dependence on beginners' field guides and aging manuals and toward greater awareness of modern taxonomic literature and distributional studies, it will serve a valuable function indeed.

The sections on history, which might have been especially valuable, unfortunately are not. The absence of Goldie's *Diary,* Macoun's *Autobiography,* and Penhallow's *Review of Canadian botany* indicates how inadequate the survey of historical literature is. (Here there would be no reason to limit citations to recent publications.) In welcome contrast, the listing of books on edible, poisonous, and medicinal plants is extensive and will be appreciated by the many persons becoming interested in these topics. Other bibliographies deal with phytogeography, ecology, horticulture, botanical journals, and maps.

The literature citations vary in format and detail and sometimes in accuracy, and will thereby sometimes cause unnecessary difficulties with interlibrary loans.

Finally, there is a list of the native and naturalized herbaceous flowering plant species of Ontario (grasses and sedges excluded, rushes included). This list was rather uncritically compiled, with unsubstantiated occurrences inferred from general statements of ranges in manuals, and with duplications such as *Frasera caroliniensis* and *Swertia caroliniensis.* It will, however, serve as a useful indicator of the plausibility of identifications and of additions to the known flora.

JAMES S. PRINGLE

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Flowering Plants of Massachusetts

By Vernon Ahmadjian. 1979. University of Massachusetts Press, Amherst. 582 pp., illus. U.S. $12.95.

This book, as pointed out by the author, is intended as a guide to the common flowering plants, both native and introduced, of the state of Massachusetts. There is a simple key to the 93 families of plants of which representatives are treated. These families are arranged alphabetically within the Monocotyledons and Dicotyledons. The text for the 277 plants for which there are full page illustrations, is easily written without a great deal of detail, and comparisons are made for an additional 218 related species. Of the 277 illustrated, all but about 20 occur in eastern Canada. The book would thus be a useful tool for gaining an acquaintance with the common plants, not only of Massachusetts, but also of surrounding regions.

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The Pteridophytes of Kansas, Nebraska, South Dakota and North Dakota

By Aleta Jo Petrik-Ott. 1979. Nova Hedwigia, Beiheft 61. J. Cramer, 3301 Lehre, Germany. 332 pp. DM 100.

This is a detailed study of 65 taxa of ferns and fern allies found in the four states lying in a tier directly south of Manitoba. The author, through careful field and herbarium study has produced an excellent treatment which must be the basis for any future study of the ferns and fern allies of the region. There are detailed descriptions, together with synonomy, habitat data, time of sporulation, and distribution maps, as well as useful comments where there are problems of distribution, clarification of earlier treatments, etc. Specimen citations are given for the various counties to substantiate the dots on the Great Plains maps.

A section on unverified records, questionable collections and excluded taxa, disposes of some entities that were previously reported for the area. On the basis of the evidence provided, however, I would not have excluded *Botrychium lanceolatum*, *Lycopodium complanatum*, or *Woodsia mexicana*, and indeed, in an addendum, the last is reinstated.

In addition to the four-state distribution map for each taxon, there is a North American distribution map with a single dot in the middle of each state and province in which the taxon occurs. Such maps can be deceptive, particularly for the limits of distribution, for such taxa as *Marsilea quadrifolia*, which is introduced in Ontario at a single station north of Lake Erie, and *Phegopteris hexagonoptera*, which is known in Canada only in the Eastern Townships of Quebec and the southern parts of Ontario.

Chromosome numbers with references are given for each taxon. There is, however, no indication that counts have been made on material from the four states, and I question the usefulness of providing this data.

A detailed bibliography, a glossary, and an index are provided to complete the volume.

This study has been published in Germany as a part of a series that is available on subscription at a reduced rate, and for the present time at least is available separately. It seems a pity that it was not published by one of the universities in the four states, where it might be more readily available to local students and visitors to the region, perhaps for a longer period of time.

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ENVIRONMENT

Ecological Grading and Classification of Land-occupation and Land-use Mosaics

By Pierre Dansereau and Gilles Paré. 1977. Geographical Paper Number 58, Fisheries and Environment Canada, Ottawa. 63 pp., illus. $3.00.

This publication is divided into a theoretical contribution by Dansereau; presentation of a new system, and its practical component by Paré; and mapping methods and problems. The authors propose a system of classifying lands upon ecological criteria rather than human benefits, stressing the occupation of the land instead of its use.

Reference is often made to the Canada Land Inventory (CLI) from which the authors try to validate their own proposal. In fact, they are able to use the CLI maps and translate them into their equivalent in ELO (Ecological Land-occupation). Considering the time, personnel, budget and so on that would be needed to translate CLI into ELO and to make wide use of ELO system instead of CLI, one wonders then if it is at all useful to do it as long as CLI is a "well-tested system, astonishingly adaptable to a huge and varied territory, and carried out with much respect for regional originality by well-disciplined dedicated teams"!

But it is claimed that ELO tells more about the land. In fact, it has several advantages. The main categories and subdivisions used are ordered into linear sequences from the least used or the least productive to the most intensively used or the most productive. It emphasizes the ecological attributes of a land on thoughtful relationship bases, which include, aside from the usual mineral-, plant-, herbivore-, and carnivore-trophic levels, two higher levels: investment and control. From Dansereau's view of an ecosystem, all types of space, even human, which encompass cycling of resources affected by agents to engender products, can be considered as ecosystems.

Thus considering that the ELO system is geared to environmental phenomena, it is felt by the authors that their classification system might better reflect the true nature of things. Moreover, the ELO system puts forward ecological criteria to evaluate potentials, the latter being considered in terms of trophic level, which allow for the required corrections and transformation to be brought about depending on the end result desired.

The classification levels in the new ELO system are as follows (Table VIII):

"*Panels* (Wild, Rural, Industrial, Urban) show the regime of land occupation in the order of increasing management by man. *Blocks* indicate the progression of energy input and the shift from one group of processes to another, *types* are the exact kinds of occupation of a wide geographical range, and *trophic levels*, the 4 usual ones plus investment and control."

Some lower categories can occur only on a regional unit.

For the mapping aspect of the work, the limitation to use of the method arises as usual with the increasing generalization required by smaller-scaled maps. The applicability of the method is too detailed for the scales widely in use for mapping. The differentiation of the "panels" on a colored map is easy, but borders between the "blocks" are less easily discerned with the range of colors used. The similarity of textures make black and white map reading more confusing. Nevertheless, these problems are not peculiar to the ELO system.

There are few errors in the publication. Some were noted in the transcription of the right texture on the map of Figure 10. In Figure 8, the number 22 and 28 should be shifted by one block to the left in the matrix, and the printing of the headings of this matrix is incomplete. The interpretation of the maps also requires reference to a color chart and two tables!

As for other new classification systems proposed by Dansereau, the statement of Colinvaux (1973) might apply: "it (might) not come into wide use . . . partly for the reason that people are seldom ready to learn another new language." ELO might have better survival chances, were the authors in the CLI team. It is to be hoped that ELO will prove very good, because it is a first attempt at integrating and emphasizing ecological criteria for wide geographical mapping purposes. I recommend planners to consider using ELO for its logics and to emphasize the important ecological nature of the space we live in.

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Canadian Nature Notebook

By Aleta Karstad. 1979. McGraw-Hill Ryerson, Toronto. 144 pp., illus. $12.95.

In creating this attractive work, Aleta Karstad did what most Canadian naturalists would like to do for a year and a half — crossed the continent twice by van, stopping with her friends for long intervals to draw and describe 25 habitats representative of Canada. One such habitat is the limestone kind, which the author studied near Kingston, in the Gatineau near Ottawa, in Manitoba, and near Inuvik. The text describes the distinctive soil, rocks, plants, and animals that exist among limestone cliffs, dealing with typical trees, common snails, newts and salamanders, snakes, ferns, flowers, lichens, and mosses. Such a list implies a clinical approach which is in fact absent; rather Karstad writes beautifully and with deep understanding about the interrelationships of the habitat. She also gives useful hints: in areas where there are rattlesnakes, she suggests that you lift up ground cover by the edge that faces away from you, so that if there happens to be a rattlesnake underneath it won't see you before you see it.

Karstad's portrayal of the life and moist atmosphere of limestone cliffs is enhanced by careful line drawings which illustrate almost every page. There is a cross-section of a cliff showing layers of rock, talus, till, and mire; a rare fern; enlargements of two minute snails and a cricket; and a sundew and pitcher plant which eat insects to supplement the minerals lacking in the acidic and limy soil. All of these are fully labelled, using scientific descriptions and scientific names. There are also superb color drawings of an orchid, a butterwort, a young watersnake, and a young ribbon snake. As this variety of organisms indicates, *Canadian nature notebook* highlights hundreds of species other than the birds and mammals one usually reads about in popular books, although these are described in their place. Karstad of course emphasizes habitats rather than species per se, a welcome change from many recent popular books. The habitats described include not only obvious selections such as Ocean Beach, Tundra, and Western Rainforest, but also places with which most of us are more familiar — Great Lakes Harbor, City, Railroad Embankment. When a habitat is illustrated in soft color or by line-drawing, as most of them are, the exact location is given in a list at the back of the book so that you feel sure every detail is completely accurate.

This is not a work to read straight through at a sitting. Rather it is one to dip into at quiet intervals when you want to remember wild areas you have enjoyed, or to visualize those you hope to visit, or merely to immerse yourself in the minutia of natural history. You will surely pick up many new ideas and be well rewarded. This is a book every naturalist in Canada should savor.

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The Development of Tourism and its Potential Future in Canada North of 60° with Implications for National Parks and Related Reserves

By Bryan Smale. 1978. Working Paper Number 1, President's Committee on Northern Studies, University of Waterloo, Ontario. 61 pp. No price given.

The author states in the Conclusions that many of the questions raised at the beginning of the report remained unanswered. I must agree. The paper reviews the status quo north of 60° and for the uninitiated this is a useful exercise. For program managers and policy decision-makers, however, the paper provides little innovative thinking. The theme of the paper is that tourism has potential to bring about reverse social, economic, and environmental impacts in the North and that the agencies involved are working at cross-purposes and aggravating the situation. In particular, the author feels that the Yukon Tourism Development Strategy is too narrow in its scope and is incompatible with the objectives of Parks Canada and National Parks in the north.

In addition to the text, the paper contains a few figures, tables presenting tourism data, and a Natural Resource Use Compatibility Matrix.

This paper is interesting but not of major significance. It need not be considered in conjunction with Working Papers 2 and 3.

An International Comparison of Policies and Institutional Arrangements for National Parks and Related Reserves in Hinterland Areas

By Julia Gardner. 1978. Working Paper Number 2, President's Committee on Northern Studies, University of Waterloo, Waterloo, Ontario. 79 pp. No price given.

This paper considers the hinterland areas of Yukon, Northwest Territories, Alaska, and the Northern Territory of Australia. It examines national parks and related reserves in the context of non-renewable resource development and native interests. Results are summarized in a chart entitled "Characteristics of policies and institutional arrangements and their implications for management." The paper is replete with acronyms for various bureaucratic agencies and even with the list of abbreviations provided by the author, the reader has to read carefully to grasp fully the actors and their roles. But, the paper is well documented and researched and allows the reader to draw his own comparisons between the areas considered. A thoughtful reader could well develop his own institutional scenarios by adapting the best of the policies from each hinterland. An interesting aspect of the paper is the indication of the different policies and attitudes towards indigenous people exhibited in the different hinterlands. It is obvious that there are quite different philosophical approaches among the three nations concerned.

I found this paper to be quite interesting and thought-provoking. Reading of this paper should benefit many land and resource planners, managers and policy analysts, inspiring innovative thought to existing situations. This document can be best appreciated if read in conjunction with paper number 3 of the same series. Even a casual reader will become aware of the intricacies and convolutions involved in resource management and future planning in hinterland areas. Canada itself has much to consider in the resolution of Native Land Claims in the North. I would recommend this paper.

Decision Making for National Parks in Canada North of 60°

By Terry Fenge. 1978. Working Paper Number 3, President's Committee on Northern Studies, University of Waterloo, Waterloo, Ontario. 58 pp. No price given.

The paper can be best appreciated if read in conjunction with paper number 2 of the same series. This paper provides a detailed account of the changing "style" and substance of National Park policy formation in northern Canada. The author describes the particular attention paid to the needs and aspirations of northern natives in the park selection and planning process.

The paper is clearly written and carefully documented. It is a good account of the activities of National Parks in the North and I would recommend it to persons interested in the North and in land-use management in the North.

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MISCELLANEOUS

First in the Field

By Robert Elman. 1977. Van Nostrand Reinhold, Scarborough, Ontario. xx + 231 pp., illus. $7.95.

Until the present century, it was often possible for a naturalist to do meaningful work in a number of divergent fields. With increased knowledge and technology has come the specialization which normally precludes such a generalist approach. *First in the Field* discusses the contributions of nine naturalists of the 18th and 19th centuries selected for their significant contributions, often against great odds, to the field of natural history. The author provides enough detail both of the personal life of each man and of the time in which they lived to enable the reader to appreciate their achievements in personal and historical perspective.

Informed readers will doubtlessly disagree with some of the author's selections for inclusion in this book. Even using his single criterion of courageous and significant accomplishment in natural history, one might argue for including such men as Asa Gray, Elliott Coues, or John Muir. Discussion of Aldo Leopold, who pioneered in the fields of forestry and wildlife management and whose writings stand as enduring expressions of attitude towards man and land would have added a major recent naturalist.

The point here, however, should not be to second-guess the author's selection so much as to evaluate his contribution. Overall, the accounts are both interesting and informative. Especially well done is the chapter on John Wesley Powell, who did major work in the geology, ethnology, and hydrology of the American west. Another generalist was Louis Agassiz who was instrumental in moving scientific inquiry from books and classroom out into the field. The other naturalists included are Mark Catesby, John and William Bartram, Alexander Wilson, John Audubon, John Bachman (briefly treated in the chapter on Audubon because of his collaboration with him on *The Quadrupeds of North America*), and John Burroughs. The last, Elman notes, was not so much a naturalist as a literary publicist, a widely read author who kindled public interest in "nature study" and was a strong proponent of accurate writing in natural history.

A comparison can be made between Burroughs and the earlier naturalists such as Audubon concerning the accuracy of their observations and writing. Audubon has often been criticized for lack of scientific accuracy. Although Audubon and Burroughs both strove to report nature as it was, it is difficult not to be a product of one's time. Many early writers were primarily explorers or adventurers who wrote with excitement, and stimulated interest in the field sometimes at the expense of absolute accuracy. The author rightly points out, however, that this criticism has been carried too far. In Audubon's time, little published information existed in the field and much that was available was anecdotal. Time and further discovery has often shown men like Audubon to be both accurate and significantly ahead of their time. If Burroughs is noted for better attention to accurate detail in his writing, this is partly a reflection of a higher degree of scientific development in his era.

The pioneering naturalists discussed in this book played a key role in the development of natural science in the New World. The understanding of their life and work which can be effectively and enjoyably obtained from this book will contribute to a better understanding of ecology and the evolution of ecological thought.

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NEW TITLES

Zoology

American spiders. 1979. By Willis J. Gertsch. 2nd edition. Van Nostrand Reinhold, New York. 274 pp., illus. U.S. $24.95.

Animal behavior: its development, ecology and evolution. 1979. By Robert A. Wallace. Goodyear, Santa Monica. xxviii + 590 pp., illus. U.S. $19.95.

Animal days. 1979. By Desmond Morris. Jonathon Cape (Canadian distributor Clarke Irwin, Toronto). $15.95.

Arthropod phylogeny with special reference to insects. 1979. By H. Bruce Boudreaux. Wiley-Interscience, New York. viii + 320 pp., illus. U.S. $21.50.

*__A bibliography of British Columbia ornithology.__ 1979. By R. Wayne Campbell, Harry R. Carter, Christopher D. Shepard, and Charles J. Guiguet. Heritage Record Number 7, British Columbia Provincial Museum, Victoria. 185 pp., illus.

†**The birds and birders of Beaverhills Lake.** 1979. By Robert Lister. Edmonton Bird Club, Edmonton. 264 pp., illus. $9.50 (Proceeds to the Canadian Nature Federation).

Birds of Ontario County. Volume 6, Common Loon to Red-breasted Merganser. 1979. By J. Murray Speirs. J. M. Speirs, 1815 Altona Road, Pickering, Ontario, L1V 1M6. $5 plus postage.

*__Birds of Pacific Rim National Park.__ 1978. By David F. Hatler, R. Wayne Campbell, and Adrian Dorst. Number 20, Occasional Papers Series, British Columbia Provincial Museum, Victoria. 194 pp., illus.

Butterfly and angelfishes of the world, volume 1. 1979. By Roger C. Steene. Wiley-Interscience, New York. 144 pp. U.S. $19.95.

Butterfly and angelfishes of the world, volume 2. 1979. By Gerald R. Allen. Wiley-Interscience, New York. 144 pp. U.S. $17.50.

Catalogue and index of spring bird notes in London's newspapers 1920–1923. 1979. By W. W. Judd. Phelps Publishing, London, Ontario. $3.

Ecological methods: with particular reference to the study of insects. 1979. By T.R.E. Southwood. 2nd edition. Chapman and Hall, London and Halsted (Wiley), New York. xxiv + 524 pp., illus. U.S. $25.

Eleonora's falcon: adaptations to prey and habitat in a social raptor. 1979. By Hartmut Walter. University of Chicago Press, Chicago. xiv + 410 pp., illus. U.S. $35.

*__A field guide to the seabirds of Britain and the world.__ 1978. By G. S. Tuck and H. Heinzel. Collins, London. xxviii + 292 pp., illus. £5.25.

Fish physiology, volume 7: locomotion. 1979. Edited by W. S. Hoar and D. J. Randall. Academic Press, New York. 592 pp. U.S. $47.50.

Fish physiology, volume 8: bioenergetics and growth. 1979. Edited by W. S. Hoar, D. J. Randall, and J. R. Brett. Academic Press, New York. 808 pp. U.S. $65.

*__The freshwater fishes of Alaska.__ 1980. By James E. Morrow. Alaska Northwest, Anchorage. 300 pp., illus. U.S. $24.95 plus 75¢ postage and handling.

†**Handbook to the orders and families of living mammals.** 1979. By Timothy E. Lawlor. 2nd edition. Mad River Press, Eureka, California. 327 pp., illus. Paper U.S. $9.25 (includes postage).

*__Mammals of the eastern United States.__ 1979. By William J. Hamilton, Jr. and John O. Whitaker, Jr. 2nd edition. Cornell University Press, Ithaca. 346 pp., illus. U.S. $19.95.

The mammals of North America. 1979. By E. Raymond Hall. 2nd edition. Wiley, New York. Volume 1, 688 pp., illus. U.S. $40; volume 2, 624 pp., illus. U.S. $40; two-volume set U.S. $70.

Marine life: an illustrated encyclopedia of invertebrates in the sea. 1979. By J. D. and J. J. George. Douglas and McIntyre, Vancouver. 320 pp., illus. $40.

The physiological ecology of tunas. 1979. Edited by G. D. Sharp and A. E. Dizon. Academic Press, New York. 506 pp. U.S. $29.50.

†**Population ecology of raptors.** 1979. By Ian Newton. Buteo, Vermillion, South Dakota. 399 pp., illus. U.S. $35.

Reef fishes of the sea of Cortez: the rocky-shore fishes of the Gulf of California. 1979. By D. A. Thomson, L. T. Findley, and A. N. Kerstitch. Wiley-Interscience, Somerset, New Jersey. 302 pp., illus. U.S. $34.50.

The role of insectivorous birds in forest ecosystems. 1979. Edited by J. G. Dickson, R. N. Conner, R. R. Fleet, J. A. Jackson, and J. C. Kroll. Academic Press, New York. 400 pp. U.S. $24.

Settlement and metamorphosis of marine invertebrate larvae. 1978. Edited by Fu-Shiang Chia and Mary E. Rice. Proceedings of a symposium, Toronto, December 1977. Elsevier, New York. xii + 290 pp., illus. U.S. $25.

Sponges. 1978. By P. R. Bergquist. University of California Press, Berkeley. 268 pp., illus. U.S. $25.

Trout. 1979. By Ernest Schweibert. Dutton (Canadian distributor Clarke Irwin, Toronto). 2 volumes. $69.95.

Turtles: perspectives and research. 1979. Edited by M. Harless and H. Morlock. Wiley, New York. 695 pp. U.S. $45.

Wake of the whale. 1979. By William R. Curtsinger and Kenneth Brower. Dutton (Canadian distributor Clarke Irwin, Toronto). illus. $39.95.

Botany

Aquatic and wetland plants of southeastern United States. 1979. By Robert K. Godfrey and Jean W. Wooten. University of Georgia Press, Athens. ix + 712 pp., illus. U.S. $30.

Common Texas grasses: an illustrated guide. 1979. By Frank W. Gould. Texas A & M University Press, College Station. x + 268 pp., illus. Cloth U.S. $10.95; paper U.S. $6.95.

†**Considérations sur la symbiose fongique chez les ptérophytes.** 1979. By Bernard Boullard. Syllogeus Number 19. Musée national des Sciences naturelles, Ottawa. 58 pp., illus. Free.

***Lichens of the Alaska arctic slope.** 1979. By John W. Thomson. University of Toronto Press, Toronto. 314 pp. $35.

Pine barrens: ecosystem and landscape. 1979. Edited by Richard T. T. Forman. Academic Press, New York. 624 pp. U.S. $39.50.

Preliminary checklist of the vascular flora of Connecticut (growing without cultivation). 1979. By Joseph J. Dowhan. Connecticut Department of Environmental Protection, Hartford. x + 176 pp. U.S. $2.

Trees, shrubs and flowers to know in Ontario. 1979. By S. McKay and P. Catling. Dent, Toronto. 208 pp. $6.95.

Use of plants for the past 500 years. 1979. By Charlotte Erichsen-Brown. Breezy Creeks Press, Aurora, Ontario. 510 pp.

†**The whole fungus.** 1979. Edited by Bryce Kendrick. Proceedings of the Second International Mycological Conference, Kananaskis, Alberta. National Museum of Natural Sciences, Ottawa, and the Kananaskis Foundation. 2 volumes. 793 pp., illus. No price given.

***Wildflowers of the north.** 1979. By Ruby Gibbins Bryan. Illustrations by Muriel E. Newton-White. Highway Book Shop, Cobalt, Ontario. 218 pp., illus. $9.60.

Environment

Aerobiology: the ecological systems approach. 1979. Edited by Robert L. Edmonds. US/IBP Synthesis Series, Volume 10. Academic Press, New York. 416 pp. U.S. $21.

Analysis of ecological systems. 1979. Edited by David J. Horn, Gordon R. Stairs, and Rodger D. Mitchell. Proceedings from a colloquium, Columbia, Ohio, April 1977. Ohio State University Press, Columbia. x + 312 pp., illus. U.S. $27.50.

The benefits of environmental improvement: theory and practice. 1979. By A. Myrick Freeman III. Resources for the Future. Johns Hopkins University Press, Baltimore. xiv + 272 pp., illus. Cloth U.S. $18.50; paper U.S. $6.95.

Biogeography. 1979. By E. C. Pielou. Wiley, New York. 330 pp., illus. U.S. $22.50.

†**Biological aspects of freshwater pollution.** 1979. Edited by O. Ravera. Proceedings of a course, Joint Research Centre, Ispra, Italy, 5–9 June 1978. Pergamon Press, Oxford. 220 pp., illus. U.S. $26.

Competition for space and the structure of ecological communities. 1978. By Peter Yodzis. Springer-Verlag, New York. vi + 192 pp., illus. Paper U.S. $9.80.

The ecology of regulated streams. 1979. Edited by James V. Ward and Jack A. Stanford. Proceedings of a symposium, Erie, Pennsylvania, 18–20 April 1979. Plenum, New York. 285 pp. U.S. $35.

Ecological processes in coastal and marine systems. 1979. Edited by Robert J. Livingston. Marine Science Series, Volume 10. Proceedings of a symposium, Tallahassee, Florida 13–15 April 1978. Plenum, New York. 530 pp. U.S. $49.50.

Effects of acid precipitation on terrestrial ecosystems. 1979. Edited by T. C. Hutchinson and M. Havas. NATO Conference Series (Series I—Ecology), Volume 4. Proceedings of a symposium, Toronto, 22–26 May 1978. Plenum, New York. 630 pp. U.S. $49.50.

***Environmental impact statement glossary: a reference source for EIS writers, reviewers and citizens.** 1979. Edited by Mark Landy. Plenum, New York. 525 pp. U.S. $75.

Magnetic field effects on biological systems. 1979. Edited by Tom S. Tenforde. Plenum, New York. 110 pp. U.S. $25.

***Order in living organisms: a systems analysis of evolution.** 1979. By R. Reidl. Wiley, New York. 313 pp. U.S. $37.50.

Pollution prevention pays. 1979. By Michael G. Royston. Pergamon Press, Oxford. 200 pp., illus. Cloth U.S. $20; paper U.S. $7.

†**Public hearings on management of water resources within the Oldman River Basin: report and recommendations.** 1979. Panel chaired by A. W. Platt. Environmental Council of Alberta, Edmonton. xv + 245 pp. Free.

Systems ecology. 1979. Edited by H. H. Shugart and R. V. O'Neill. Benchmark Papers in Ecology, Volume 9. Academic Press, New York. 384 pp. U.S. $29.50.

Miscellaneous

†**Allan Brooks artist naturalist.** 1979. By Hamilton M. Laing. Special Publication 3, British Columbia Provincial Museum, Victoria. 249 pp., illus. Cloth $16; paper $10.

Alpine Canada. 1979. By Andy Russell and J. A. Kraulis. Hurtig, Edmonton. 144 pp., illus. $27.50.

†**Geological lectures by Dr. John Richardson, 1825–26.** 1979. By John Warkentin. Syllogeus Number 22, National Museum of Natural Sciences, Ottawa. 63 pp., illus. Free.

Outdoor photography. 1979. By Erwin A. Bauer. Dutton (Canadian distributor Clarke Irwin, Toronto). Paper $8.95.

Scientific and technical books and serials in print 1980. 1979. Anonymous. Bowker, New York. 2590 pp. U.S. $55.

Scientific illustration: a guide to biological, zoological and medical rendering techniques, design, printing and display. 1979. By Phyllis Wood. Van Nostrand Reinhold, New York. 148 pp. U.S. $16.95.

The scientist as editor: guidelines for editors of books and journals. 1979. By Maeve O'Connor. Wiley, New York. 218 pp. U.S. $12.50.

†**The Stikine River.** 1979. Edited by R. A. Henning, M. Loken, and B. Olds. Volume 6, Number 4. Alaska Geographic, Edmonds, Washington. 96 pp., illus. Paper U.S. $11.95.

Technical books and monographs: 1979 catalogue: 1979. By U.S. Department of Energy. National Technical Information Service, Springfield, Virginia. 162 pp. U.S. $3.75.

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†Available for review

Instructions to Contributors

Content

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The **Council of Biology Editors Style Manual**, 4th edition (1978) available from the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

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Cover: Young White Whale in Fire Island Inlet, New York in late July 1979. This whale was seen in Fire Island Inlet and adjacent Great South Bay between March and mid-October 1979 and was photographed by Frank Keating, *Newsday*. See article on page 239.

The Canadian Field-Naturalist

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Distribution and Abundance of Birds on the Arctic Coastal Plain of Northern Yukon and Adjacent Northwest Territories, 1971–1976

RICHARD E. SALTER, MICHAEL A. GOLLOP, STEPHEN R. JOHNSON, WILLIAM R. KOSKI, and C. ERIC TULL

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Observations on avian distribution, abundance, habitat relationships, and seasonal movements are summarized. A total of 122 species was recorded: at least 46 (and possibly an additional 14) nest in the area. Known breeding ranges of Brant (*Branta bernicla*), Mallard (*Anas platyrhynchos*), Pintail (*Anas acuta*), American Wigeon (*Anas americana*), Northern Shoveler (*Anas clypeata*), scaup (*Aythya* spp.), Pectoral Sandpiper (*Calidris melanotos*), Stilt Sandpiper (*Micropalama himantopus*), Buff-breasted Sandpiper (*Tryngites subruficollis*), Red Phalarope (*Phalaropus fulicarius*), Say's Phoebe (*Sayornis saya*), Yellow Wagtail (*Motacilla flava*), Yellow Warbler (*Dendroica petechia*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Fox Sparrow (*Passerella iliaca*) are extended. The study area is the main fall staging region for post-breeding Snow Geese (*Chen caerulescens*) of the western Canadian Arctic, and includes an important molting site for Oldsquaws (*Clangula hyemalis*) and Surf Scoters (*Melanitta perspicillata*). The coast is a major migration route for various waterfowl and shorebirds. Only Gyrfalcon (*Falco rusticolus*), Willow Ptarmigan (*Lagopus lagopus*), Snowy Owl (*Nyctea scandiaca*), and Common Raven (*Corvus corax*) are known to remain during winter. The avifaunas of the Canadian and Alaskan portions of the Coastal Plain are similar, with the primary exception that Asiatic, Beringian, and maritime stragglers are confined largely to the Alaskan portion.

Key Words: birds, Arctic Coastal Plain, Yukon, abundance, nesting, migration, geographical distribution, habitat.

On fait le résumé d'observations sur la distribution, l'abondance, les relations d'habitat, et les déplacements saisonniers de l'avifaune. On y a enregistré 122 espèces; au moins 46 (et possiblement 14 en plus) nichent dans la région. On a constaté l'extension des aires de nidification déjà connues de la Bernache cravant (*Branta bernicla*), du Canard malard (*Anas platyrhynchos*), du Canard pilet (*Anas acuta*), du Canard siffleur d'Amérique (*Anas americana*), du Canard souchet (*Anas clypeata*), du Morillon (*Aythya* spp.), du Bécasseau à poitrine cendrée (*Calidris melanotos*), du Bécasseau à échasses (*Micropalama himantopus*), du Bécasseau roussâtre (*Tryngites subruficollis*), du Phalarope roux (*Phalaropus fulicarius*), du Moucherolle à ventre roux (*Sayornis saya*), de la Bergeronnette printanière (*Motacilla flava*), de la Fauvette jaune (*Dendroica petechia*), du Pinson à couronne blanche (*Zonotrichia leucophrys*), et du Pinson fauve (*Passerella iliaca*). L'aie à l'étude est la région principale d'assemblement pour la migration d'automne des Oies blanches (*Chen caerulescens*) de l'ouest de l'arctique canadienne après la saison reproductive, et elle comprend une aire importante pour la mue des Canards kakawis (*Clangula hyemalis*) et des Macreuses à front blanc (*Melanitta perspicillata*). La côte est une route importante pour la migration de plusieurs espèces de sauvagines et d'oiseaux de rivage. Le Gerfaut (*Falco rusticolus*), le Lagopède des saules (*Lagopus lagopus*), le Harfang des neiges (*Nyctea scandiaca*), et le Grand Corbeau (*Corvus corax*) sont les seules espèces qui y restent pendant l'hiver. Les avifaunes des parties de la plaine côtière au Canada et en Alaska sont similaires, à l'exception principalement des individus errants asiatiques, béringiens ou maritimes qu'on retrouve généralement dans la partie de l'Alaska.

Mots clefs: oiseaux, plaine côtière de l'arctique, Yukon, abondance, nidification, migration, distribution géographique, habitat.

The Arctic Coastal Plain of extreme northwestern Canada is an area of low arctic tundra situated between high mountains to the south, the Beaufort Sea to the north, and the forested Mackenzie Delta to the east. It has a rich and varied avifauna, with species from woodland, tundra, and marine habitats. This avifauna, however, was poorly known before recent studies associated with proposed resource development (see [Johnson et al., report number 26 in Reports Cited][1] for literature review). Early records (dating

[1] References in square brackets refer to reports in the Arctic Gas Biological Report Series or the Beaufort Sea Technical Report Series in Reports Cited section (see Table 1).

from the late 1800s and early 1900s, and summarized by Rand 1946) came primarily from coastal areas because of the difficulty of travel inland. Recent studies have not been so restricted, and have often been more systematic and quantitative. During 1971–1976 LGL Limited conducted several studies in this area for both industry and government. In this paper, we summarize data obtained during this period on avian distribution, abundance, habitat relationships, and seasonal movements. We also provide a guide to reports that present the original data on which this summary is based.

Study Area

The area for which records are summarized encompasses a narrow strip of extreme northern Yukon and adjacent Northwest Territories, bounded on the west by the Alaska-Yukon border and on the east and northeast by the western edge of the Mackenzie Delta (Figure 1). The northern boundary is the Beaufort Sea to the limit of visibility from the coast of offshore islands. The arbitrary southern boundary is the 305-m (1000-ft) contour from the Alaska border to the vicinity of Cache Creek, then east along 68°25′N to the Mackenzie Delta. The study area measures ~250 km east–west and a maximum of ~55 km north–south.

This region encompasses the Canadian portion of the Arctic Coastal Plain (Bostock 1961; Welsh and Rigby 1971), a natural physiographic unit that reaches its greatest extent in Alaska (Wahrhaftig 1965). Its southern margin rises into the Arctic Plateau, a rolling foothill area 305–610 m asl bordering the British, Barn (Figure 2), and Richardson mountains, and extending southward between the mountains along the upper reaches of Babbage and Blow rivers. The mountains reach maximum elevations of 1600 m 50–100 km from the coast.

From the 305-m contour the Coastal Plain slopes gradually down to sea-level, with little local relief except along incised river valleys. Drainage is through numerous rivers and streams. The area is underlain by continuous permafrost, and polygonal ground and other permafrost-related features are prominent. Concentrations of small lakes are characteristic, particularly on the eastern part of the plain and near the coast. Vegetation cover is a mosaic of dry tussock, wet sedge, and low shrub tundra types, with tall brush (< 3 m) in drainage courses and around some

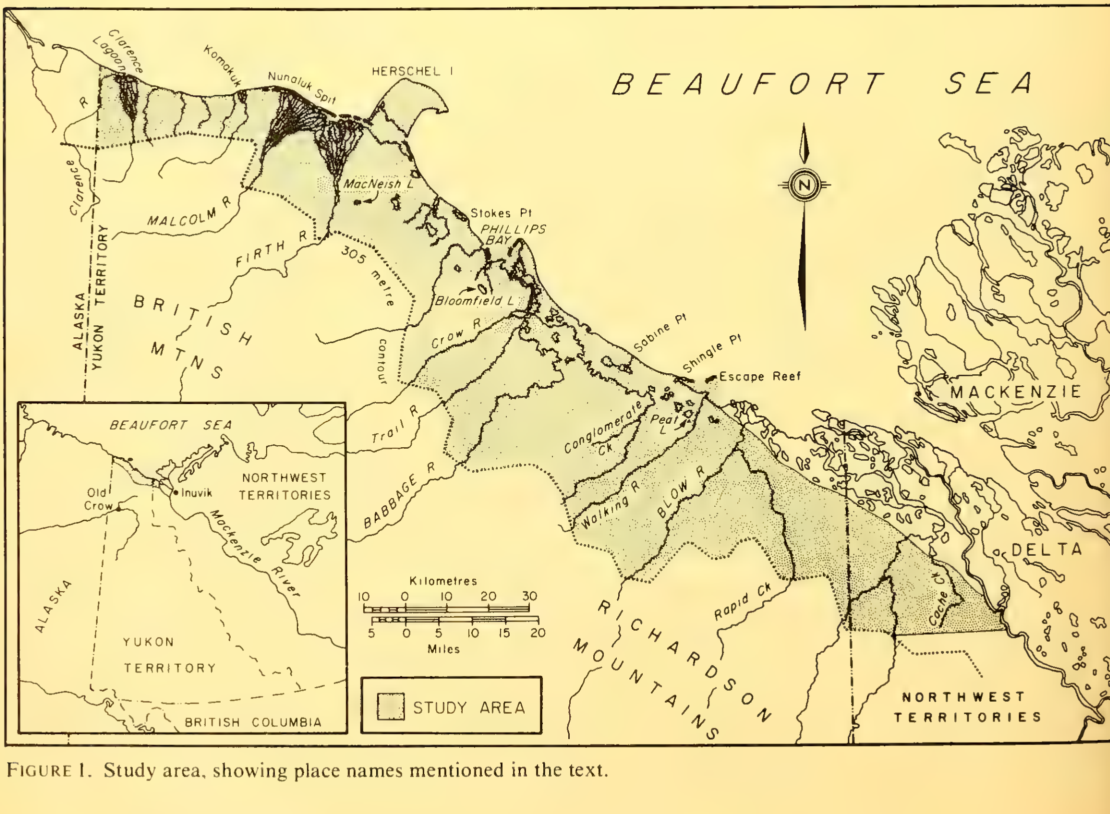

FIGURE 1. Study area, showing place names mentioned in the text.

FIGURE 2. View south from the upper Babbage River area, showing the Arctic Coastal Plain in the foreground with the Barn Mountains beyond. Note the predominance of tussock-heath tundra in this area.

lakeshores.

The Beaufort Sea coast is characterized by stretches of low, sandy or silty cliffs and narrow beaches that are interspersed with river deltas, barrier islands, spits and lagoons (Figure 3). Herschel Island, physiographically similar to the mainland and separated from it by only 3 km, is the only major offshore landmass.

Permanent human settlements are limited to two DEW sites: Komakuk, 30 km from the Alaska border, and Shingle Point, near the westernmost edge of the Mackenzie Delta. Herschel Island was an important whaling center around the turn of the century, and until the last decade was the location of an RCMP post. The buildings are now occupied seasonally by families from the Mackenzie Delta area.

Much of the study area is included within a recently proposed national wilderness park.

Climate and Phenology

The climate is Polar Continental, characterized by long cold winters and short cool summers. Mean daily temperatures reach a low of nearly −30°C in February, surpass 0°C in June, are highest in July (7°C Komakuk, 11°C Shingle Point) and fall below 0°C again in October (Burns 1973). Extremes of −53°C and +29°C have been recorded. Frost and snow can occur in any month. Mean yearly precipitation is 12.5 cm at Komakuk and 19 cm at Shingle Point: about 55% falls as rain, primarily during July and August. There is considerable seasonal variation from year to year.

Timing of snow and ice melt critically influences habitat availability to birds arriving in spring. Snow melt begins about 10–15 d before mean daily temperatures reach 0°C (Bird 1967); snow-free areas are generally present at the end of May. Most of the snow disappears by mid-June, but some persists on unexposed slopes and in drainage courses into late June and occasionally early July.

Deltas of the larger rivers provide the first available habitat for arriving waterfowl and other waterbirds. Open water may be present on some deltas as early as mid-May. Peak runoff occurs in late May or early June, by which time major streams are largely ice-free. Melt-water begins to appear along lake margins by late May, and most lakes are ice-free by late June.

Polar ice-pack covers the Beaufort Sea for 8–9 mo of the year, although intermittent cracks, leads, and polynyas may be open offshore throughout the winter. Open water begins to appear along the coastline in late May or early June, primarily at the mouths of rivers and creeks; waterbirds arriving in spring make use of this open water along shore. Cracks in the sea ice begin to open up by mid-June, and the ice-pack generally disappears from nearshore areas by mid-July.

FIGURE 3. View west along the Beaufort Sea coast from the landward end of Nunaluk Spit. Coastal lagoons are in the foreground, with Nanaluk Spit stretching off towards the right of the photograph.

Severe storms with strong northwest winds and blowing snow occur along the coast during late August and September; they may blow floating ice back toward shore. Mean daily temperatures drop substantially during September and are consistently below freezing by October. Winter snowfall can begin by early September. By late September most of the lakes have frozen over and by late October or early November ice cover is again continuous over the Beaufort Sea.

Methods

Various ornithological studies were conducted during 1971–1976 (Table 1). Observers were present primarily during May–September, but occasionally in October and January–April. Studies were of two basic types: (1) baseline studies to determine species, numbers, and activities of birds, and (2) disturbance studies to determine the impacts on birds of various kinds of disturbance associated with pipeline construction or operation. Most studies were for Canadian Arctic Gas Study Limited, whose proposed pipeline would have traversed the study area; others were for the Canadian Wildlife Service (Beaufort Sea Project) to determine the status of birds in the Beaufort Sea before offshore drilling. For further details the reader is referred to the original reports of studies listed in Table 1.

Species Accounts

The following accounts summarize records from studies listed in Table 1 and from unpublished field notes. All data are from sight records. Species are ranked as follows:

- abundant (A): observed each year, preferred habitat(s) widespread, occurred throughout preferred habitat(s) and/or in migration in consistently high numbers;
- common (C): as above, but in moderate numbers;
- fairly common (FC): as above, but numbers low or variable;
- uncommon (U): usually observed each year, occurred in low numbers or in restricted habitats;
- rare (R): observed in two or more years, observations sporadic, usually no more than a few locality records in any year; or
- very rare (VR): less than five records during study.

Status is given as follows:

- permanent resident (pr): some individuals present year-long;
- summer resident (sr): evidence of breeding, but present only seasonally;
- spring or fall migrant (spm, fm, or m): present only during migration periods, or changing in abundance during migration; or
- visitant (v): regular to infrequent visitors.

TABLE 1—Ornithological studies conducted by LGL Limited on the Arctic Coastal Plain, 1971–1976

No.[1]	Study	Date	Location
1*	8 aerial surveys to identify important breeding, molting, and staging areas	18 June–10 September 1971	Proposed pipeline route across Coastal Plain
	4 aerial surveys at monthly intervals to determine use of areas by waterfowl	6 June–9 September 1971	Deltas of Malcolm, Firth, and Babbage rivers
	Ground surveys of breeding and post-breeding birds along strip transects through various habitats	18 June–5 August 1971	Sites at Cache Creek, Blow River, Phillips Bay, Firth River, Nunaluk Spit, Clarence Lagoon
	Visual counts of fall migrants	24 August–6 September 1971	Nunaluk Spit
2*	Control plot and study plot with gas compressor sound simulator to assess effects of such noise on nesting terrestrial birds	20 May–25 July 1972	Babbage River 19 km SE of Phillips Bay
3*	Control plot and study plots for aircraft disturbance and human presence to assess effects of each on nesting terrestrial birds	24 May–7 July 1972	Firth River (MacNeish Lake)
4*	Visual counts of spring and fall migrants	8 June–17 September 1972	Nunaluk Spit, Komakuk (4 d)
5*	Visual observations of disturbance to nesting waterbirds by aircraft and human presence; monitoring of marked nests to determine effects of disturbance	11 June–12 July 1972	Nunaluk Spit, Phillips Bay
6*	Visual observations of waterfowl behavior on control lakes and lakes subjected to repeated landing of aircraft	20–25 June 1972	5 lakes between Phillips Bay and Blow River
7*	Ground observations to determine populations and productivity of waterbirds on various types of lakes	23–29 July 1972	22 lakes between Firth and Walking rivers
8*	Visual observations of normal behavior of molting sea ducks and of effects of repeated overflights	6–14 August 1972	South shore of Herschel Island
9*	Visual observations of reaction of staging Snow Geese to aircraft overflights and of effects of repeated overflights	3–4 September 1972	W of Komakuk
10*	Visual observations of reaction of staging Snow Geese to gas compressor sound simulator noise	7–10 September 1972	4 km SE of Komakuk
11*	6 plot censuses of breeding terrestrial birds in tundra habitat and comparative transects through plots	30 May–25 June 1973	Babbage River 35 km SE of Phillips Bay
12*	Ground surveys of breeding birds along strip transects through various habitats	21–26 June 1973	6 sites as in study 1
13*	Ground transects through 1972 breeding terrestrial bird disturbance and control plots	9, 14 July 1973	Sites as in studies 2 and 3
14*	As in study 7	24–29 July 1973	60 lakes between Firth and Blow rivers
15*	4 aerial surveys to inventory characteristics and usage of brood-rearing and molting areas	17 June–30 August 1973	Beaufort Sea coast, Alaska border to Shingle Point
16*	As in study 8	2–15 August 1973	South shore of Herschel Island

TABLE 1—*(concluded)*

No.[1]	Study	Date	Location
17†	Weekly aerial surveys and ground observations of distribution and movements of staging Snow Geese, other geese, and Whistling Swans; also ground observations of other fall migrants	23 August–30 September 1973	Transect grid of Coastal Plain; camps at Shingle Point, Blow River, Bloomfield Lake, Komakuk
18*	As in study 10	25 August–28 September 1973	2 km S of Komakuk
19†	Visual observations of normal behavior of staging Snow Geese and their reactions to aircraft overflights	30 August–21 September 1973	Komakuk, Bloomfield Lake, Shingle Point, Blow River
20†	Analysis of fat content to study energetics of staging Snow Geese	1–26 September 1973	Shingle Point (Jacob's Lake)
21**	Visual observations of breeding behavior of Gyrfalcons and of their reactions to helicopter overflights	21 March–3 July 1974	Various locations on Coastal Plain
22*	As in study 12, two coverages at each site	9 June–11 July 1974	Sites at Cache Creek, Blow River, Babbage River, Firth River, Clarence Lagoon
23*	Weekly aerial surveys of distribution and movements of staging Snow Geese, other geese, and Whistling Swans	24 August–30 September 1974	Transect grid of Coastal Plain plus surveys along the coastline
24**	Aerial surveys to determine winter distribution of Gyrfalcons and ptarmigan	15 January–25 February 1975	As in study 21
	As in study 21	25 March–1 July 1975	As in study 21
25,26††	Radar and visual observations of spring migrants and aerial surveys of open water areas	9 May–9 July 1975	Komakuk, Clarence Lagoon, Beaufort Sea coast
27*	4 aerial surveys along reroute of proposed pipeline	5 June–30 August 1975	Reroute W to Conglomerate Creek
28*	As in study 12	8–9 July 1975	1 site at Blow River
29*	As in study 23	20 August–25 September 1975	As in study 23
*	Aerial survey of late fall distribution of Gyrfalcons	21–23 October 1975	As in study 21
30*	As in study 23, plus ground observations	15 August–2 October 1976	As in study 23, camp at Shingle Point

[1] These numbers have been used in the Reports Cited to refer to the various studies.
* Study conducted for Canadian Arctic Gas Study Limited.
† Study conducted cooperatively by LGL Limited (for Canadian Arctic Gas Study Limited) and by Canadian Wildlife Service.
**Study conducted for Canadian Arctic Gas Study Limited with support from Canadian Wildlife Service.
††Study conducted for Canadian Wildlife Service and Beaufort Sea Project.

Species for which only indirect evidence of nesting was obtained (i.e., breeding or distraction displays, repeated sightings of pairs or singing males) are indicated as (sr?). Dates of earliest and latest observations are given for abundant through uncommon species; these dates reflect to some extent the timing of our activities in the region, but unless otherwise stated are considered to provide a good indication of the period during which each species can be expected to occur. (Because of seasonal variation the dates of earliest observation of some of the earlier-arriving species may be based on observations in a single year. Observers were present before 20 May only in 1974, a 'late' year, and 1975, a comparatively normal year.) Additional information pertinent to occurrence, breeding, or migration is provided under most species accounts because of the paucity of published information on this area. The numbers of waterbirds seen on surveys of 22 lakes in 1972 and 60 lakes in 1973 are summarized in Table 2.

Nomenclature follows the AOU Check-list (1957) and Supplements (1973, 1976). Habitat types men-

TABLE 2—Numbers of loons, grebes, and waterfowl observed during ground-based counts of lakes on the Arctic Coastal Plain, 1972 and 1973

Species	1972 counts (22 lakes)*			1973 counts (60 lakes)*		
	Frequency	No. of adults	No. of broods	Frequency	No. of adults	No. of broods
Common Loon	0	0	0	3	4	0
Arctic Loon	15	57	4	50	213	20
Red-throated Loon	3	5	0	9	15	0
Loon spp.	2	3	0	3	5	0
Horned Grebe	0	0	0	1	2	0
Whistling Swan	7	13	2	18	39	5
Canada Goose	0	0	0	1	1	0
Mallard	1	1	0	3	4	0
Pintail	9	32	4	31	161	9
Green-winged Teal	3	4	3	10	21	5
American Wigeon	1	4	3	1	20	2
Northern Shoveler	0	0	0	1	1	1
Canvasback	0	0	0	1	2	0
Scaup spp.	8	190	9	23	221	10
Oldsquaw	9	365	14	40	1046	33
Harlequin Duck	1	1	0	0	0	0
White-winged Scoter	0	0	0	2	13	0
Red-breasted Merganser	2	4	1	11	26	0
Duck spp.	5	56	5	18	565	8

*From Gollop and Davis, report number 10 in Reports Cited.
†From Sharp et al., report number 14 in Reports Cited.

tioned in the text are described for contiguous areas of Alaska by Kessel and Cade (1958), Andersson (1973), and Sage (1974).

COMMON LOON. *Gavia immer.* Uv (31 May–10 September). Present primarily at coastal locations during June–August, but also inland (two at Cache Creek, 9 June 1974; one east of Bloomfield Lake, 15 June 1973). Recorded at Nunaluk Spit during fall migration studies in 1971 (16 W,[2] 10 E) and 1972 (8 W, 4 E).

YELLOW-BILLED LOON. *Gavia adamsii.* Uv (28 May–17 September). Somewhat more numerous than Common Loon; observed in small numbers during spring migration (47 birds, 28 May–15 June 1975, Komakuk and Clarence Lagoon), both in offshore waters and moving E along the coast. Occasional on nearshore marine waters and on lakes near the coast in summer, and along the coastline during fall migration W (90 at Nunaluk Spit, 10 July–17 September 1972, many possibly repeats). Observed inland only along Babbage River (two on 10 June 1974).

ARCTIC LOON. *Gavia arctica.* Csr (31 May–25 September). The most abundant loon in the area, breeding on tundra lakes throughout. Mean size of 19 broods was 1.4 (range 1–2). Extensive use also was made of marine habitats. During coastal spring migration past Clarence Lagoon and Komakuk in 1975 most movement was E. An influx of presumed non-breeders occurred at Komakuk late June – early July 1975, when a large nearshore lead was present. A movement E past Nunaluk Spit in July 1972 also may have involved largely immatures and non-breeding adults. Remained until late September along the coast, both in sheltered bays and on open ocean; observed in fall migration past Nunaluk Spit in both 1971 (1 E, 20 W) and 1972 (179 E, 63 W).

RED-THROATED LOON. *Gavia stellata.* FCsr (30 May–12 September). Observed migrating E past Clarence Lagoon 5–14 June 1975; widespread between there and Blow River during summer, in association with tundra lakes and with lagoons and bays along the coast. Three nests were found (one egg, Clarence Lagoon, 26 June 1975; two eggs, lower Babbage River, 29 June 1972; one egg same vicinity, 21 July 1972). Small flights E past Nunaluk Spit occurred mid-July to mid-August 1972 (67 E, 26 W); later movements were largely W (37 E, 70 W, 24 August–6 September 1971; 8 E, 22 W, 14 August–17 September 1972).

RED-NECKED GREBE. *Podiceps grisegena.* VRv. Three records: Clarence Lagoon (one on open water in lagoon, 1 June 1975), Komakuk (one flying over pond, 17 June 1975),

[2]16 birds flying west. Flight directions are abbreviated throughout the species accounts.

and Bloomfield Lake (one adult, probably the same bird, on 21, 23, 28, 29, and 30 August 1973).

HORNED GREBE. *Podiceps auritus*. VRv. One observed on Peat Lake, 25 June 1972; two on a small lake 6 km S of Phillips Bay, 25 July 1973; one to three sightings daily at Bloomfield Lake, in association with scaup and Oldsquaws, 14–17 September 1973.

WHISTLING SWAN. *Olor columbianus*. FCsr (19 May–2 October). Earliest spring record three flying W at high altitude over Komakuk (1975); other early arrivals were observed on deltas of Firth and Malcolm rivers (20 May 1973) where open water was present earlier than on any inland lake. Spring migrants moved W both along the coastline (19 May–2 June 1975, Clarence Lagoon and Komakuk) and inland (31 May 1972, lower Babbage River). Sporadic movements W occurred at Komakuk and Clarence Lagoon until 13 June in 1975; these may have been either local movements or final stages of spring migration. Probably nested near tundra lakes throughout the area (e.g., nest with two eggs, Blow River, 26 June 1973) but appeared to be most common in the vicinity of the Babbage River. Mean size of seven broods observed during late July (1972–1973) was 3.3 (range 1–4). Birds observed along the coast in summer (Phillips Bay) were probably mostly non-breeders or unsuccessful breeders. Small numbers observed migrating E past Nunaluk Spit in 1971 (102 E, 60 W) and 1972 (89 E, 0 W) late August – early September, with stragglers until late September; in 1973 E migration near Komakuk peaked 25–27 September (439 birds in 3 d).

CANADA GOOSE. *Branta canadensis*. R(sr?), Uspfm (28 May–15 September). Migrants moved W in spring, both along the coast (32 past Komakuk, 29 May–3 June 1975) and inland (nine over lower Babbage River, 31 May 1972; 12 over Firth River, 4 June 1972). Scattered records of similar magnitude throughout June may have been of late spring migrants, but the possibility of localized breeding is suggested by sightings in the Blow River area (one pair 10 June 1974; two pairs 4 July 1974). Fall migration proceeded E along the coast (119 past Nunaluk Spit, 29 August–5 September 1971; 'several' in a mixed flock of White-fronted and Snow Geese same location, 15 September 1972). According to AOU (1957) Canada Geese along the Beaufort Sea coast are *B. c. parvipes*; we noted that individuals were medium-sized and fairly light in coloration but did not make subspecific identifications.

BRANT. *Branta bernicla*. Usr, Cspfm (27 May–28 September). Virtually all Brant observed were the dark-bellied form; only occasional light individuals were seen. Only small numbers observed inland in spring (70 E over Firth River, 27 May 1972; 16 W over lower Babbage River, 2 June 1972; 11 NW same location, 7 June 1972), but observations at Komakuk and Clarence Lagoon in 1975 (total 17 530 birds, with peak movement on 7 June) indicated that a wide corridor was followed in primarily E migration, with flocks occurring as far offshore and inland as observers were able to see and identify them. Some spring migrants stopped along the coast (500 on open water on Firth River delta, 8 June 1972) but few remained into the summer. Nests were found only on a small island off the east tip of Nunaluk Spit (two nests with four eggs each, 23 June 1972). When checked on 1 and 3 July, one nest contained three eggs and the other two, but both had been destroyed by 12 July. Non-breeding adults also were observed in this area during June and July. Fall migration along the coastline at Nunaluk Spit peaked in late August in both 1971 and 1972; flight direction was almost exclusively W. Nearly 15 000 birds were observed during the 1971 study (24 August–6 September); migrants flew over the ocean at low altitude about 100–200 m from shore. From mid-August to mid-September flocks were commonly observed resting and feeding in river deltas and lagoons all along the Yukon coast. Migrants were rarely observed inland in fall.

WHITE-FRONTED GOOSE. *Anser albifrons*. Uspm, Rv, Cfm (15 May–26 September). Observed both along the coast and inland during spring, primarily moving W (largest daily total [non-systematic counts] 124 W over lower Babbage River, 28 May 1972), and at inland and coastal sites west of Babbage River from mid-June to mid-August. Fall migratory movements began in late August and peaked in the first half of September. Substantially more birds were seen in fall than spring migration. Migrating flocks flew along the shoreline and up to several kilometres inland; simultaneous peaks were observed 10–11 September 1973 at three sites (10 046 at Komakuk; 20 175 at Bloomfield Lake; 11 500 at Shingle Point), movement being almost entirely E. During most years few migrants stopped in the study area (maximum ~2000, 5 September 1976).

SNOW GOOSE. *Chen caerulescens*. Uspm, VRv, Afm (13 May–26 September). Recorded in spring at both inland and coastal locations, engaging in both E and W movements with no clear trend. Largest daily total (non-systematic counts) was 314 W over lower Babbage River, 28 May 1972. Flocks of four and five birds observed at Nunaluk Spit on 24 June 1973 and 25 June 1971, respectively, constitute our only mid-summer records. An influx of geese occurred during mid-August (13–23 August, 1971–1976) as 2000–5000 primarily non-breeding or failed-breeding birds arrived from breeding areas to the east. A second, larger influx consisting of post-breeding adults and young-of-the-year occurred ~10 d later (22 August–3 September, 1971–1976). Maximum numbers estimated to have been present in late summer varied between 260 000 (1973) and 55 000 (1975, a year when freezing weather preceded the arrival of the geese). Feeding flocks dispersed along the Coastal Plain from the Mackenzie Delta west to Marsh Creek in Alaska, and from near the coastline into the lower foothills. Departure from the staging area was variable (7–26 September, 1971–1976); it was usually rapid and seemed to be induced by freezing weather conditions. Intensive surveys showed the Coastal Plain to be the major autumn pre-migration staging site of the western Canadian population of Snow Goose (breeding on Banks Island and in the Anderson River delta).

MALLARD. *Anas platyrhynchos*. Rsr. Singles and pairs recorded on 10 occasions on lakes and rivers between the Blow and Firth rivers, 27 May–15 September. Bred in the area in limited numbers, as indicated by pair sightings and by a female with four young on Conglomerate Creek, 26 August 1976. Coastal records consist of one pair W past Clarence Lagoon 6 June 1975, one male W past the same location 5

July 1975, and several E past Nunaluk Spit with a flock of Pintails in late August 1972.

PINTAIL. *Anas acuta.* FCsr, Cm (17 May–17 September). Occurred both inland and along the coast in early spring (e.g., five E at lower Babbage River 24 May 1972; pair E at Clarence Lagoon, 25 May 1975), engaging in both E and W movements along the coast late May – early July, and occurring throughout the area in summer. Confirmed as breeding between Blow and Firth rivers; active nests were found at Firth River (one in 1972) and upper Babbage River (three in 1973), all in dwarf shrub habitat. The Firth River nest had seven eggs 9–25 June, but had been destroyed by 28 June. The first nest found at Babbage River had two eggs on 30 May but was abandoned by 3 June; the fate of the other two nests was not determined. An additional deserted nest with eight eggs was found 25 July 1973 near Babbage River. Pintails were the most numerous and widespread dabbling duck on tundra lakes; mean size of 12 broods was 4.4 (range 2–9). Pintails were occasionally observed around Nunaluk Spit and Herschel Island in July and early August, when migration began; movements past Nunaluk Spit were primarily E (396 E, 16 W, 1971; 3324 E, 432 W, 1972) and peaked near the end of August in both years. Migrants usually flew directly along the coastline, occasionally landing on lagoons.

GREEN-WINGED TEAL. *Anas crecca.* Usr (27 May–17 September). Frequently recorded along the coast in spring and early summer (48 records Clarence Lagoon and Komakuk, 29 May–26 June 1975), occurring in summer throughout the area and confirmed as breeding at eight sites (one nest, eight broods) between Blow and Firth rivers. The nest was found at lower Babbage River in 1972; nest construction began 6 June with a completed clutch of seven eggs by 14 June. Mean size of six broods seen on lakes in late July was 4.3 (range 1–9). Infrequently recorded along the coastline late summer – early fall (2 W past Nunaluk Spit, 24 July 1972; 1 E with a flock of Pintails same location, 1 September 1972).

AMERICAN WIGEON. *Anas americana.* Rsr. First recorded 31 May, and observed in summer at scattered locations throughout the area. The majority of records were from the vicinity of Babbage River. No nests were found, but adults and broods were observed on a lake 1 km E of Babbage River and 18 km SE of Phillips Bay in both 1972 and 1973; brood sizes were four, five, and seven in 1972. Coastal records were obtained at Clarence Lagoon (25, 2 June–6 July 1975), Phillips Bay (mixed flock of American Wigeon and Pintails on alluvial plain, 22 June 1971), Nunaluk Spit (44 W and 6 E, 16–20 August 1972), and Komakuk (seven during June 1975; one on 2 September 1973).

NORTHERN SHOVELER. *Anas clypeata.* VRsr. Earliest record four at lower Babbage River, 29 May 1972; also recorded in spring at Komakuk (one male W, 30 May 1975), at Clarence Lagoon (pair in sedge-grass marsh, 30 May 1975; one male W, 19 June 1975), and at Nunaluk Spit (2 E, 9 June 1972). Observed on a lake 18 km SE of Phillips Bay in both 1972 (23 June) and 1973 (25 July); the latter record consisted of a female and brood of six.

CANVASBACK. *Aythya valisineria.* VRv. Observed at only three locations: lake at Blow River (five adults, 25 July 1971), lake 1 km E of Babbage River and 18 km SE of Phillips Bay (one adult, 21 and 22 June 1972), and lake midway between Bloomfield Lake and Firth River, 16 km S of coast (two adult males, 24 July 1973).

GREATER/LESSER SCAUP. *Aythya marila/A. affinis.* Csr (26 May–26 September). We were unable consistently to differentiate Greater and Lesser Scaup, but confirmed sightings of both species were obtained (e.g., 14 Greater Scaup at Clarence Lagoon and Komakuk, 1–18 June 1975; six Lesser Scaup at same sites, 31 May–17 June 1975). From these and other sightings Greater Scaup appeared to predominate. Scaup were second only to Oldsquaws in abundance on tundra lakes. Breeding was confirmed by brood sightings between Blow and Firth rivers. Mean size of 17 broods in 1972–1973 was 4.8 (range 1–9). Observed along the coast from late May until well into September; moved E, probably to molting areas, in early July (128 E, 59 W past Nunaluk Spit 1972, primarily during 10–16 July). In early August small but undetermined numbers were present among large flocks of molting Oldsquaws and Surf Scoters south of Herschel Island.

COMMON GOLDENEYE. *Bucephala clangula.* Rv. Single male in breeding plumage at Clarence Lagoon, 26 June 1975. Common Goldeneye also were observed in association with scoters, Oldsquaws, and mergansers at Herschel Island during the molt period (nine records, 8–15 August 1973). A further five goldeneye were observed during an aerial survey of the Coastal Plain on 2 September 1971, but could not be identified to species.

BARROW'S GOLDENEYE. *Bucephala islandica.* VRv. Male entering eclipse plumage (crescent-shaped patch behind bill still evident) on lake near Blow River, 25 July 1971.

OLDSQUAW. *Clangula hyemalis.* Asr (28 May–28 September). Movement into the area began in late May and continued for at least 2 wk (45.4 birds/h E past Clarence Lagoon 29 May 1975; peak rate 268.0 birds/h E past Komakuk 11 June 1975). The Oldsquaw was the most numerous duck on the Coastal Plain, breeding from Cache Creek to Firth River and probably west to the Alaska-Yukon border. Mean size of 46 broods during 1972–1973 lake surveys was 6.1 (range 1–13). Many of the adults present on lakes in late July appeared to be molting. Marine areas, however, probably constituted the primary molting habitat. Flights W along the coast at Nunaluk Spit in mid-July probably represented movement of birds to Alaskan molting areas. Herschel Island was the only important molting area along the Yukon coast; Oldsquaws and Surf Scoters constituted the vast majority of the estimated 5000–10 000 molting ducks observed in early August 1971–1973 in the sheltered waters between this island and the mainland. Migratory movements began late August (e.g., net movement W of nearly 1000 birds, Nunaluk Spit, 25 August–6 September 1971). In 1973, sightings of migrants were made at Bloomfield Lake (7 km inland) until 28 September.

HARLEQUIN DUCK. *Histrionicus histrionicus.* Rv. The few records obtained showed that this species utilized a variety of aquatic habitats, including rivers (one male on lower Babbage River, 1 June 1972); lakes (one adult on 400-ha lake 23 km S of Phillips Bay, 25 July 1972); inshore waters,

lagoons, and bays (two males on open water at seaward margin of Clarence Lagoon, 27 June 1975; several sightings on the sheltered water south of Herschel Island, 2–15 August 1973); and open ocean (one adult resting on ocean at Nunaluk Spit, 11 August 1972). (Breeding was not documented within the study area, but on 25 August 1976 a female with four young was observed on the Firth River, ~13 km upstream of the southern boundary.)

COMMON EIDER. *Somateria mollissima.* Usr (3 June–26 September). Sightings limited to coastal area between Herschel Island and Clarence Lagoon. Spring migration data (1975) showed an initial movement E (maximum 30.8 birds/h at Komakuk, 11 June); after mid-June observed flying both E and W past Komakuk and Clarence Lagoon. Early arrivals used available open water along the coast (~40 on open water of Firth River delta, 8 June 1972) and offshore (732 in leads during offshore aerial surveys, 5 June 1975). Breeding records centered on a small island off the east tip of Nunaluk Spit, where 20 nests with 71 eggs (range 0–8) were counted 25 June 1971. These were in a mixed colony with Glaucous Gulls; one nest had two eider and two gull eggs. A total of 34 eider nests (clutch size 0–13) was counted in this colony 23 June–4 July 1972, and although nest records were incomplete at least 17 were known to have been lost to predators. Single nests were found at a lake edge at Komakuk (five eggs, 19 June 1975) and on Nunaluk Spit (four eggs, 24 June 1973). At least eight different broods frequented lagoons near Nunaluk Spit 31 July–28 August 1972. A general movement W was in progress when regular observation periods were initiated at Nunaluk Spit on 10 July 1972. This continued until 20 August, but less than 400 birds were seen in total. Much of the eider movement through this area may occur too far offshore to be detected by observation from the coast. A few eiders were observed in the area south of Herschel Island in August 1973, among much larger flocks of Oldsquaws and Surf Scoters. A male examined in hand was *S. m. v. nigra*; this is the only subspecies known to occur along the Beaufort Sea coast (AOU 1957).

KING EIDER. *Somateria spectabilis.* Um (13 May–7 September). Observations limited to the coastal area and apparently to spring and fall migrants. A total of 44 was seen from Komakuk and Clarence Lagoon 13 May–28 June 1975, but more (304) were observed on aerial surveys offshore. Spring observations during other years also occurred within this period (three at Nunaluk Spit, 10–12 June 1972; 11 at Clarence Lagoon, 15 June 1974). No records were obtained during July. King Eiders were observed in early August at Nunaluk Spit (one male, 1 August 1973) and Clarence Lagoon (one, 5 August 1971), and also from mid-August into September at Nunaluk Spit and Shingle Point.

WHITE-WINGED SCOTER. *Melanitta deglandi.* FCv (1 June–6 September). Observed at several locations between Blow River and Clarence Lagoon, but nowhere in large numbers. Total of 194 observed during migration watches at Komakuk and Clarence Lagoon, 6 June–9 July 1975; moved E (20 of 26 birds) during the first week of this period. Occurred occasionally on tundra lakes and along the coastline (rafting in small mixed flocks with Surf Scoters at Nunaluk Spit 24 June 1971, and with Surf Scoters and Oldsquaws at Herschel Island in early August 1973). This species may leave the region early for molting grounds elsewhere; White-winged Scoters were not positively identified on the Coastal Plain or along the coastline after mid-August, with the exception of a flock of four flying over Bloomfield Lake 6 September 1973.

SURF SCOTER. *Melanitta perspicillata.* Cv (29 May–15 September). Recorded at very few inland locations (two males upper Babbage River, 29 May 1973; one male same location, 8 June 1973; two at lower Babbage River, 20–25 June 1972; single males at each of two lakes near Blow River, 15 km S of coast, 24 July 1973), but locally abundant in large flocks along the coast (e.g., 400 on coastal survey between Phillips Bay and Nunaluk Spit, 21 June 1973; 1600 off south shore of Herschel Island during aerial survey, 25 July 1972). Flocks of 40 and 50 birds were observed flying and landing in the water off Nunaluk Spit 24–25 July 1971, and a cumulative total of nearly 500 (including an undetermined but probably small number of White-winged Scoters) was observed feeding on the ocean just offshore from this location 10 July–18 August 1972. Large-scale movement along the coast, possibly to molting grounds in Alaska, was observed from Nunaluk Spit during June–August (~500, mostly males, W on 24 June 1973; estimated 6280 [possibly including some White-winged Scoters] W, 10–25 July 1972; 117 W, 16 August 1972); large numbers also molted at Herschel Island (5000–10 000 molting sea ducks, mostly Oldsquaws and Surf Scoters, early August 1971–1973). During 1975 migration studies at Komakuk and Clarence Lagoon a movement W (mostly males) occurred 17 June–9 July.

BLACK SCOTER. *Melanitta nigra.* Rv. Single males at Clarence Lagoon, 8 June 1975, and at Nunaluk Spit 11, 12, and 28 July 1972. A flock of four at Clarence Lagoon on 21 June 1975 is our only other record for the study area, although on an aerial survey on 26 June 1975 a flock of 30 was seen flying over open water ~2 km N of Herschel Island.

RED-BREASTED MERGANSER. *Mergus serrator.* Usr (26 May–25 September). Observed at both inland and coastal sites between Blow River and Clarence Lagoon. Three broods recorded: two young at MacNeish Lake, 31 July 1971; nine young at lake 2 km E of Babbage River, 24 July 1972; seven young at Bloomfield Lake, 3–25 September 1973. A few Red-breasted Mergansers occurred among the large flocks of molting sea ducks at Herschel Island in August. They were recorded at Nunaluk Spit and Komakuk during fall migration, but movement patterns were unclear. In 1971, 79 were observed at Nunaluk Spit 3–6 September, all flying W along the coast, but in 1972 movement was largely E during this period.

SHARP-SHINNED HAWK. *Accipiter striatus.* VRv. One at lower Babbage River, flying E, 28 May 1972; one at Cache Creek, 5 July 1974.

RED-TAILED HAWK. *Buteo jamaicensis.* VRv. One dark-phase bird on upper Rapid Creek, near the foothills, 1 May 1974.

ROUGH-LEGGED HAWK. *Buteo lagopus.* Usr (16 May–29 September). Both light- and dark-phase birds observed throughout the area. At least 13 nest sites were found within the study area, but only limited clutch data were obtained. Active nests were found both on the mainland (four eggs,

upper Babbage River, 7–20 June 1973) and Herschel Island (at least two nests produced fledglings 1973). Latest observations at Komakuk (one on 27 September 1973) and Bloomfield Lake (one on 29 September 1973).

GOLDEN EAGLE. *Aquila chrysaetos.* Usr (26 April–25 September). Both adults and flying immatures recorded throughout the area. At least 19 nest sites were found on cliffs and buttes within the study area, but clutch data were not obtained. (In British and Richardson mountains to the south, egg-laying occurred in early to mid-May and young fledged mid- to late August).

BALD EAGLE. *Haliaeetus leucocephalus.* VRv. Recorded at upper Babbage River (one immature, 28 May 1973), Blow River (one adult, 10 June 1974), between Babbage and Firth rivers (one at caribou kill, 19 June 1972), and at Komakuk (one on 2 September 1973).

MARSH HAWK. *Circus cyaneus.* Uv (16 May–18 September). Widely distributed between Cache Creek and Clarence Lagoon, both inland and along the coast. Recorded each year but not regularly observed in any one area. Although both sexes were observed we found no evidence of breeding on the Coastal Plain.

OSPREY. *Pandion haliaetus.* VRv. One at Shingle Point 23 August 1973; one at Blow River 15 September 1973.

GYRFALCON. *Falco rusticolus.* Upr. Observed at scattered locations throughout the area. Intensive surveys located 22 nest sites on bluffs and cliffs; not all were active in any year. At least 25 young were produced at 10 sites in 1973, 13+ young at four sites in 1974, five young at two sites in 1975, and 18 young at six sites in 1976 (1973 data courtesy R. Fyfe, Canadian Wildlife Service; 1976 data courtesy D. Mossop, Yukon Game Branch; as *cited in* [Platt and Tull, report number 24 of Reports Cited]). Seen regularly along the coast in fall (e.g., 15 sightings, Shingle Point, 22 August–29 September 1973; 20 sightings, Blow River, 11–22 September 1973), possibly following the shorebird and waterfowl migrations. Adults were present at nest cliffs during winter (January, February, and October 1975), when the main food was ptarmigan; immatures probably moved out of the area during winter (Platt 1976).

PEREGRINE FALCON. *Falco peregrinus.* Rsr. Observed less frequently than Gyrfalcon, but recorded at scattered locations between Blow River and Clarence Lagoon. Earliest record one at upper Babbage River, 11 May 1974. A few nest sites were located on the study area, but not all were active. Peregrines were sighted at several coastal locations during August. Latest observation one at Shingle Point, 17 September 1973.

MERLIN. *Falco columbarius.* VRv. One at Phillips Bay, 28 May 1972; four records at Shingle Point (possibly all the same bird), 21 August–15 September 1973.

AMERICAN KESTREL. *Falco sparverius.* Vrv. Female at upper Rapid Creek, near foothills, 4 May 1974.

WILLOW PTARMIGAN. *Lagopus lagopus.* Apr. Found breeding in suitable habitat throughout the area. Territorial densities in predominantly tussock-heath tundra were 9.5/km^2 (lower Babbage River, 1972), 12.7/km^2 (Firth River, 1972), and 11.8/km^2 (upper Babbage River, 1973). Territorial males were present in upper Babbage River area by 20 May 1973. Clutch sizes ranged up to 13, but it was not possible to calculate a mean because many nests were destroyed by predators before we could determine whether clutches were complete. Nest sites were usually associated with small patches of dwarf shrub in tussock-heath tundra, although overall habitat preference was for tall brush. Flocks of up to 400 birds were observed in this habitat (along rivers and streams) during winter (January–February 1975; see Platt 1976).

ROCK PTARMIGAN. *Lagopus mutus.* FCsr (9 May–22 September). Less numerous than Willow Ptarmigan but observed throughout the area. Flocks of 7–18 frequented snow-free patches of tundra at Clarence Lagoon and Komakuk 9–19 May 1975; after 19 May no more than three per group were recorded. During the snow-free period Rock Ptarmigan showed a preference for dry tundra but also were recorded in other habitats. Population densities derived from plot data were 8.5 territories/km^2 at Firth River in 1972 and 1.3 territories/km^2 at upper Babbage River in 1973. A nest located in Firth River area had a completed clutch of nine eggs. At upper Babbage River, Rock Ptarmigan preferred steep hillsides with little overlap onto flat tussock-heath tundra preferred by Willow Ptarmigan. Flocks of up to 15 were regularly observed in Nunaluk Spit area July–September 1972, frequenting piles of driftwood near the shoreline.

SANDHILL CRANE. *Grus canadensis.* Uv (20 May–23 September). Observed at both inland and coastal sites during spring (e.g., 1 N over upper Babbage River, 28 May 1973; six at Clarence Lagoon, 31 May–2 June 1975), some arriving earlier than indicated above (recorded at Komakuk 14 May 1975 by an Inuk resident). Present between Phillips Bay and Clarence Lagoon June–August, from limited data apparently preferring extensive areas of sedge-grass marsh within a few kilometres of the coast. No evidence of breeding was obtained. Migrated E both along the coast and inland (Bloomfield Lake) during September, but observed only in low numbers (maximum 18 at Shingle Point, 11 September 1973).

SEMIPALMATED PLOVER. *Charadrius semipalmatus.* R(sr?). Occasionally observed in association with braided rivers inland (Trail, Firth, Crow, Babbage, and Blow rivers) and on gravel beaches along the coast (Herschel Island, Nunaluk Spit, Komakuk, and Clarence Lagoon). Earliest record one at Clarence Lagoon, 27 May 1975; latest record one along a beach at Herschel Island, 4 August 1973. Probably bred within the study area (displaying bird at Clarence Lagoon, June 1975) but no nests were found.

KILLDEER. *Charadrius vociferus.* VRv. Recorded only at Clarence Lagoon (two feeding in sedge-grass marsh, 21 June 1975; one flying over lagoon and calling, 7 July 1975).

AMERICAN GOLDEN PLOVER. *Pluvialis dominica.* Asr (17 May–16 September). Found throughout the area in a variety of habitat types with preference for tussock-heath and dry tundra as nesting habitat. Territorial densities derived from plot data were 4.2/km^2 (lower Babbage River, 1972), 12.7/km^2 (Firth River, 1972), and 5.0/km^2 (upper Babbage

River, 1973). Territorial displays first noted early June. Mean size of eight completed clutches was 3.9 (range 3–4). Over 1000 plovers (including some Black-bellied) were recorded in fall migration during 2 mo of observation at Nunaluk Spit in 1972; movement was primarily E and peaked the last half of August, although stragglers were noted well into September.

BLACK-BELLIED PLOVER. *Pluvialis squatarola.* Um (30 May–2 September). Observed at scattered inland and coastal locations between Cache Creek and Clarence Lagoon, but no evidence of breeding.

RUDDY TURNSTONE. *Arenaria interpres.* Um (18 May–3 September). Occurred almost exclusively along the coast, but migration patterns and directions not well-defined (e.g., of 22 seen in directed flight at Komakuk and Clarence Lagoon 25 May–13 June 1975, 8 were flying W, 11 E, and 3 N or S). Fall migrants observed at Nunaluk Spit (18 E, 11 W, 5 S, 4 August–3 September 1972; present by 27 July 1973), Clarence Lagoon (one on 5 August 1971), Herschel Island (two on 12 August 1972), and Blow River (two on 21 August 1973).

COMMON SNIPE. *Capella gallinago.* FC(sr?) (26 May–30 August). Observed at several inland sites between Cache Creek and Firth River, and near the coast at Shingle Point, Komakuk, and Clarence Lagoon, either in sedge-grass marsh around lakes or in polygonal tundra. Repeated aerial territorial displays observed at lower Babbage River (1972), upper Babbage River (1973), and Komakuk and Clarence Lagoon (1975), but no nests were found.

WHIMBREL. *Numenius phaeopus.* Usr (26 May–30 August). Observations at inland locations between Cache Creek and Firth River, primarily during June–July, indicate that Whimbrels probably bred in suitable habitat throughout the area. Three nests were found, two at lower Babbage River in 1972 and one at upper Babbage River in 1973. At least two nests were located in tussock-heath tundra (one habitat unrecorded) and all contained completed clutches of four eggs. Territories were located in tussock-heath tundra at the upper Babbage River in 1973 (estimated $1.9/km^2$). Only coastal records are one at Clarence Lagoon 30 May 1975, three at same location 8 June 1975, and 10 E past Nunaluk Spit 20–30 August 1972.

SPOTTED SANDPIPER. *Actitis macularia.* R(sr?). Recorded at five or more locations near Babbage River, in association with gravel river beds and beaches along lakeshores, mid-June to late July; only other record one at Cache Creek, 9 June 1974. Likely bred in low numbers although no nests were found.

LESSER YELLOWLEGS. *Tringa flavipes.* Rv. Six records at inland locations between Cache Creek and Stokes Point, 4 June–25 July (all singles). Also observed along the coast at Nunaluk Spit (1 W, 10 August 1972) and at Shingle Point (undetermined number 21, 22, 23, and 29 August 1973).

RED KNOT. *Calidris canutus.* VRv. Singles at Nunaluk Spit 8 June 1972 and at Clarence Lagoon 19, 20, and 21 June 1975 (male with worn breeding plumage, in sedge-grass marsh habitat, presumably same bird each day).

PECTORAL SANDPIPER. *Calidris melanotos.* Csr (24 May–19 September). Found in association with tussock-heath tundra and sedge-grass marsh, with an apparent preference for sedge-grass marsh after the breeding season. Single nest found at Firth River (maximum three eggs, 9 June–1 July 1972) and lower Babbage River (four eggs, 9 July 1974). Nests also found at Komakuk (three) and Clarence Lagoon (four) in 1975 but completed clutch data were not obtained. Recorded at 7 of 22 and 36 of 60 lakes surveyed in late July 1972 and 1973, in flocks of up to 30. Immatures were present near at least seven lakes between Shingle Point and Firth River during 1973 surveys. Numerous at Nunaluk Spit during fall migration periods of 1971 (166 E, 1 W) and 1972 (407 E, 20 W, and using the delta of Malcolm River). Migratory movement peaked late August – early September. Observations at Herschel Island and at Komakuk in 1973 confirmed large fall movements along the coast. Spring migrants also occurred along the coast, but movement patterns were not well defined. Of 297 birds in directed flight at Komakuk and Clarence Lagoon 28 May–12 June 1975, 55% were moving E, 45% W; others were feeding or resting.

WHITE-RUMPED SANDPIPER. *Calidris fuscicollis.* Rm. Recorded at Nunaluk Spit 1972–1973: records of seven birds (six flying, one feeding), 9 June–16 August. Also observed at Komakuk (two flying, 9 June 1975) and at Clarence Lagoon (two flushed from sedge-grass marsh, 11 June 1975).

BAIRD'S SANDPIPER. *Calidris bairdii.* FCsr (28 May–9 August). During spring migration in 1975 this species was much more abundant at Komakuk than at Clarence Lagoon (239 vs. 9 observed), probably as a result of preference for dry tundra habitat around the former site (but see [Johnson et al., report number 26, of Reports Cited]). Movement E peaked at the end of May in 1975. On 26 June 1975 a nest with four eggs was found in dry tundra at Komakuk; this was the only evidence of breeding, although birds were observed at both inland and coastal locations between Phillips Bay and Clarence Lagoon during the breeding season. Only occasionally identified during fall migration studies along the coast in July and early August.

LEAST SANDPIPER. *Calidris minutilla.* U(sr?) (28 May–29 July). Records widely distributed between Cache Creek and Clarence Lagoon, in association with both sedge-grass marsh and lacustrine waters. Appeared to be resident at upper Babbage River in June 1973, but a displaying male at this location on 5 June was the only indication of breeding activity.

DUNLIN. *Calidris alpina.* Rv. Total of 39 at Komakuk (flocks of up to 25 birds) and two at Clarence Lagoon, 28 May–12 June 1975. Previous to 1975 we had obtained only one record, one at Blow River, 4 July 1974.

SEMIPALMATED SANDPIPER. *Calidris pusilla.* Asr (27 May–29 August). Associated most frequently with sedge-grass marsh but also recorded in tussock-heath tundra. Occurred in suitable habitat throughout the area; probably the most numerous breeding shorebird on the Coastal Plain. Mean size of seven completed clutches was 3.8 (range 3–4). Small flocks, including in some cases flying immatures, were recorded at 10 of 22 (1972) and 25 of 60 (1973) lakes surveyed

during late July. Flocks gathered along the coast throughout July and August. Also occurred along the coast during spring migration.

SANDERLING. *Calidris alba.* Rv, Um (27 May–5 September). Only sporadically observed at inland locations, primarily near Babbage River (at least 10, in flocks of one to three, 28 May–29 July), but apparently somewhat more numerous along the coast (over 200, Herschel Island–Clarence Lagoon, 27 May–5 September). Numbers in spring (total 11, 1975) were too low to discern movement patterns. In contrast, 88% of the 186 birds observed at Nunaluk Spit 17 July–5 September 1972 were moving W.

LONG-BILLED DOWITCHER. *Limnodromus scolopaceus.* U(sr?) (22 May–25 September). Dowitchers (presumably Long-billed from the known range; AOU 1957) were recorded at several sites between Blow River and Clarence Lagoon late May – late July, with an apparent preference for sedge-grass marsh habitat. Five birds recorded at upper Babbage River 29 May–8 June 1973, but none resident in the area. Present at seven of 60 lakes surveyed late July 1973; flying immatures recorded at two. No nests were found but a female giving a distraction display was sighted 11 July 1974 at Firth River. Dowitchers migrated E along the coast during late August – early September. Nearly 800 were recorded at Nunaluk Spit 15 August–15 September 1972. Flocks were occasionally observed along the landward shores of coastal lagoons during this period but most records were of flying birds. In contrast to the numbers of fall migrants along the coast, only 12 dowitchers were observed at Komakuk and Clarence Lagoon in spring migration in 1975.

STILT SANDPIPER. *Micropalama himantopus.* Usr (28 May–7 August). Recorded along the coast in spring, in apparent migration E (Komakuk, 29 May–7 June 1975; peak rate 3.0 birds/h) and at scattered locations throughout the study area June–July. Found nesting only near Clarence Lagoon (3 km S of site; four eggs, 15 June 1975) but an adult with three young was observed 8 July 1975 near Blow River, and an adult was observed giving a distraction display 11 July 1974 at Firth River. A total of seven birds was recorded at six of 60 lakes surveyed during late July 1973, in association with sedge-grass marsh.

BUFF-BREASTED SANDPIPER. *Tryngites subruficollis.* Usr (27 May–22 August). Recorded between Blow River and Clarence Lagoon, with an apparent center of abundance between Babbage and Firth rivers. Displaying birds were observed 27 May (upper Babbage River 1973) – 25 June (Malcolm River delta 1971), but display was most intense the first week of June (Firth River 1972). Display territories were located in tussock-heath tundra, which was also the primary nesting habitat (see Prevett and Barr 1976, for details of breeding behavior). Eight nests were discovered in Firth River area in 1972 but only three were followed to completion (one had three eggs, the others four). A single nest in lower Babbage River area in 1972 had four eggs on 29 June. Recorded during fall migration only at Nunaluk Spit (5 W, 10 August 1972; 11 E, 22 August 1972). The latter birds were with Pectoral Sandpipers, so other Buff-breasted Sandpipers may have passed undetected in mixed flocks of shorebirds. The paucity of spring records along the coast (four at Komakuk, 1975) also suggests, however, that the coastline may not be an important migration route.

HUDSONIAN GODWIT. *Limosa haemastica.* Rv. Singles and pairs observed at inland and coastal locations between Blow River and Clarence Lagoon 30 May–2 August, but no evidence of nesting.

RED PHALAROPE. *Phalaropus fulicarius.* Usr (31 May–5 September). Recorded at inland sites in the vicinity of Blow, Babbage, and Firth rivers during first 2 weeks of June, but the majority of records were obtained along the coast. Spring migration occurred 31 May–10 June in 1975 and proceeded primarily E; 63 and 383 birds were observed at Komakuk and Clarence Lagoon during this period, with peak movement rates of ~6 birds/h. A nest with four eggs was found in sedge-grass marsh habitat at Clarence Lagoon 21 June 1975. Observed elsewhere along the coast and inland during summer, but no other nests were found. Between 30 July and 5 September 1972 large numbers frequented the lagoons and spits at Nunaluk Spit, associating with Northern Phalaropes, which outnumbered them by ~20 to 1 in identified samples. Observed daily (1–25 birds) at Herschel Island 1–15 August 1973.

NORTHERN PHALAROPE. *Lobipes lobatus.* Asr (20 May–17 September). Observed throughout the study area. Nests found at Firth River and lower Babbage River in 1972, and at upper Babbage River in 1973. Mean size of four completed clutches 3.5 (range 3–4). Clutch initiation began early June; an incubating male was still present on one lower Babbage River nest 6 July. Nests were located in tussock-heath tundra and in polygonal areas in the immediate vicinity of tundra pools. Breeding density at lower Babbage River in 1972 was estimated at 7.3 territories/km^2. Observed at 37 of 60 lakes surveyed in late July 1973, singly or in small flocks, some of which included immature birds. A maximum of 185 was counted around one lakeshore. Preferred habitat during this period appeared to be sedge-grass marsh. Phalarope flocks also were abundant along the coast at Nunaluk Spit, particularly after the end of July. Thousands of phalaropes (mostly Northern Phalaropes) frequented lagoons west of the spit in early August 1972; fall migration was largely E (6149 E, 3484 W). Approximately 5000 birds were seen at Herschel Island during the first half of August 1973. Although Northern Phalaropes also occurred along the coast during spring migration studies (1975), numbers seen were much lower than during fall migration.

POMARINE JAEGER. *Stercorarius pomarinus.* Cspm, Rv (28 May–26 September). The most commonly observed jaeger during spring migration studies at Komakuk and Clarence Lagoon in 1975; an initial movement E 29 May–12 June (with peak rates of 33.5 and 31.9 birds/h at Clarence Lagoon 7 and 11 June) was followed by a substantial emigration W (first noted at Komakuk 11 June; peak rates of 28.4 and 27.9 birds/h at Clarence Lagoon 18 and 19 June). Previous observations at lower Babbage River, Firth River, and Nunaluk Spit had suggested an eastward movement of birds in late May (1972), and although a subsequent return W was not previously documented this species was certainly rare during summer and fall in all years (see Maher 1974, regarding abandonment of nesting areas soon after spring arrival in some years).

PARASITIC JAEGER. *Stercorarius parasiticus.* Csr (22 May–28 September). Observed throughout the study area, foraging over a wide variety of habitats. Five nests were found, all on tussocks in wet polygonal tundra; completed clutch size one or two (two nests each). Observed at 17 of 60 lakes surveyed in late July 1973, although only one or two were present at each lake. Movements and abundance after July were apparently closely tied to the activities of phalaropes, which were hunted persistently. Numbers observed along the coast in 1972 peaked during August, coinciding with the peak abundance of phalaropes.

LONG-TAILED JAEGER. *Stercorarius longicaudus.* Csr (20 May–28 September). Widely distributed between Cache Creek and Clarence Lagoon. Although nests were found only at lower Babbage River (one in 1972, two in 1973 — all two-egg clutches), territorial displays and calls noted at other locations in 1973 suggested that breeding may occur throughout the area in years of lemming abundance. Present at 20 of 60 lakes surveyed in 1973. A few records obtained at both inland and coastal sites well into September, but uncommon in the area after first week of August.

GLAUCOUS GULL. *Larus hyperboreus.* Csr (11 May–22 October). Observed from Blow River westward, up to several kilometres inland. Records at upper Babbage River in 1973 indicated a possible migration from some inland point towards coastal areas in spring (2 on 26 May, 12 NW on 27 May, 79 NW on 29 May, 11 N on 3 June) but most migratory movement was probably along the coast (sporadic movements E at Komakuk and Clarence Lagoon, 15–27 May 1975, with peak migration E 28 May–21 June, adults preceding second- and third-year birds). Nested on Clarence River delta and on at least six offshore barrier islands between Escape Reef and Nunaluk Spit, using associated coastal habitat for feeding. Mean clutch size of 41 nests studied during 1972 was 2.5 eggs (range 1–3). Clutches were complete by 23 June, and most young had hatched by 12 July. Daily local feeding movements occurred along the coastline at Nunaluk Spit July – early September 1972. Some scavenging and limited nesting also occurred inland; Glaucous Gulls were observed at 3 of 22 and 9 of 60 lakes surveyed in late July 1972 and 1973, and solitary nests were found at two lakes (one south of Shingle Point, one near Clarence Lagoon) in 1975. Migration W along the coast began mid-September in 1972. This species was still present along the coast and inland in other years on the latest dates on which observers were present (34 at Komakuk 28 September 1973; one at Bloomfield Lake 29 September 1973; one immature along Babbage River 22 October 1975). One reportedly overwintered at the Komakuk garbage dump in 1974–1975.

ICELAND GULL. *Larus glaucoides.* VRv. An immature gull seen perched at Nunaluk Spit (5 September 1972) was identified as this species after careful examination under good lighting conditions.

HERRING/THAYER'S GULL. *Larus argentatus/L. thayeri.* Uv (21 May–28 September). Both species were positively identified within the study area, but the two were rarely distinguished and we are unable to comment on their relative abundance. Herring/Thayer's Gulls were observed at scattered inland and coastal sites but seemed to be most numerous along the coast. Both adults and juveniles observed; there was no evidence of nesting.

MEW GULL. *Larus canus.* Rv. Recorded at upper Babbage River (single records, 26 and 30 May, 2 and 3 June 1973), at Clarence Lagoon (six observed, 12–29 June 1975), at Komakuk (six observed, 16–21 June 1975) and at Shingle Point (one adult, 30 August 1973; one immature, 28 September 1973).

BONAPARTE'S GULL. *Larus philadelphia.* VRv. Two and one N over upper Babbage River 27 and 28 May 1973 constitute our only records for the area. (A small nesting colony found in 1971 on the Old Crow Flats, south of the present study area, represents a westward extension of the known breeding range and may have been the source of the above birds. A minimum of 12 birds was present at this colony 12–13 June 1971 and two nests were found; 15 birds were present at a second site in the Old Crow Flats 14 June 1971 but a search for nests was not conducted.)

LITTLE GULL. *Larus minutus.* VRv. Observed only at Komakuk, where two adults seen feeding over sedge-grass marsh 16 June 1975; two adults flying NW over the sea ice 17 June may have been the same individuals (see Johnson and Adams 1977).

IVORY GULL. *Pagophila eburnea.* VRv. One at Shingle Point 7 September 1973.

KITTIWAKE. *Rissa* sp. VRv. Six W past Nunaluk Spit 7 August 1972, 1 E 11 d later. From the known range these were probably Black-legged Kittiwakes, *R. tridactyla* (AOU 1957).

SABINE'S GULL. *Xema sabini.* Rv. Observed along the coastline at Nunaluk Spit (51, 8–13 June 1972; one, 11 July 1972; one, 8 August 1971), at Komakuk (11, 4 June–6 July 1975) and at Clarence Lagoon (47, 4 June–6 July 1975). An additional record was obtained during aerial surveys along the coast in fall (one, 14 September 1975). Spring movement patterns appeared to vary among years; all but one bird seen at Nunaluk Spit in June 1972 were flying W, while at Clarence Lagoon 4–13 June 1975 most flying birds were moving E (36 E, 3 W). The only inland record (20 km from the coast) was of seven at lower Babbage River 5 June 1972.

ARCTIC TERN. *Sterna paradisaea.* Asr (27 May–5 September). Early arrivals seen at both inland and coastal sites; during 1975, migration along the coast occurred late May to mid-June and was primarily E. Widely distributed around tundra lakes (17 of 22 and 45 of 60 surveyed late July 1972 and 1973) and along the coast, nesting on offshore barrier islands and in association with tundra-lacustrine edges, including sedge-grass marsh and peat beaches. Six nests found in association with lakeshores or wet tundra had one or two eggs but none was followed to completion. Completed clutch size of 11 nests studied during 1972 on an island off the tip of Nunaluk Spit was 1.3 (range 1–2). At the latter location no nests were present on 12 June but clutches were complete by 23 June, and some young had hatched by 12 July. On 7 August 1971 at least 47 fledged young were present at this island, most of them capable of flight. Local feeding flights recorded at Nunaluk Spit July–August 1972. Migration occurred mid-August and was largely W. Terns were not observed at coastal locations after 5 September, indicating a relatively early departure.

MURRE. *Uria* sp. VRv. Two birds identified as murres were observed flying W past Herschel Island, 8 August 1973. From the known range (AOU 1957) they were likely Thick-billed Murres, *U. lomvia*.

BLACK GUILLEMOT. *Cepphus grylle*. Rsr. Observations limited to the coastal area west of and including Herschel Island. At least 10 active nests were found in abandoned buildings on Herschel Island 12 August 1973 (records included in Kuyt et al. 1976); most birds observed in the region (up to 62 km W and 2 km N) presumably were associated with this colony. The earliest record is of 2 W past Komakuk 17 May 1975. In 1972 singles were observed flying past Nunaluk Spit until 16 August, but dates of migration from the Herschel Island colony were not determined.

SNOWY OWL. *Nyctea scandiaca*. Upr. Singles and pairs recorded each year at several inland and coastal sites, but no evidence of breeding. An influx of owls was noted 16 September 1974; at this time ~220 were present between Shingle Point and Phillips Bay, at an average density of $\sim 1/km^2$. Three were seen in January 1975, two in river valleys, one on sea ice.

SHORT-EARED OWL. *Asio flammeus*. Usr (15 May–18 September). Widely distributed throughout the study area, including coastal sites. Observed at both Komakuk (95 birds) and Clarence Lagoon (104) during 1975 spring migration studies; E movement predominated May – early June. A nest with seven eggs and with two adults in attendance was found near Clarence Lagoon 17 June 1975. Two birds were resident in upper Babbage River area 26 May–25 June 1973, but no evidence of breeding was found at this site.

COMMON NIGHTHAWK. *Chordeiles minor*. VRv. One flying at Bloomfield Lake., evening of 12 September 1973.

COMMON FLICKER. *Colaptes auratus*. VRv. One (Yellow-shafted) Flicker was observed perched on a piece of driftwood at Clarence Lagoon 8 June 1975.

SAY'S PHOEBE. *Sayornis saya*. Rsr. Observations limited to western half of study area. Only one nest was found (incubating bird and four eggs on embankment along Crow River, 19 km S of coast, 15 June 1975), but other observations were suggestive of nesting. A pair was observed carrying nest material into a communications tower at Komakuk 16 June 1975, but although they remained in the area for at least two more days the nest was not completed. During 1973, one or two birds were regularly observed subsequent to 7 June near a cliff face at upper Babbage River, but no further evidence of nesting was obtained. One at Crow River 21 July 1972 constitutes our only other record.

HORNED LARK. *Eremophila alpestris*. U(sr?). One of the first species to arrive in spring (20 at Komakuk, 14–20 May 1975; four at Sabine Point, 19 May 1972; pair at upper Babbage River, 20 May 1973). Although no nests were found, observations of displaying males at upper Babbage River 30 May–9 June 1973, and of a female feeding three recently fledged young at Herschel Island 7 August 1973, indicate breeding activity. At least three pairs were present along a ridgetop at upper Babbage River late May – early June 1973. Further records of one or two birds obtained at Cache Creek, Blow River, Crow River, Herschel Island, Komakuk, and Clarence Lagoon, 14 June–12 September. Preferred habitat was dry tundra, usually along hilltops or ridges where gravel and rock were exposed.

TREE SWALLOW. *Iridoprocne bicolor*. Rv. Three at lower Babbage River, 28 May 1972; two at upper Babbage River, 8 June 1973. Migrant flocks of Bank Swallows observed at Herschel Island 5 and 6 August 1973 also contained some Tree Swallows.

BANK SWALLOW. *Riparia riparia*. Rv. Observed early in the season at upper Babbage River (two on 6 June 1973) and at Komakuk and Clarence Lagoon (two at each location, 7–14 June 1975). During 1973, 137 swallows in flocks of 2–40 were observed flying E past Herschel Island 5 August (16:00–18:00 YST) and 6 August (06:30–07:45); most were Bank Swallows, with 10% or less Tree Swallows. A single Bank Swallow at Shingle Point 16 September 1973 constitutes our latest record.

BARN SWALLOW. *Hirundo rustica*. VRv. One at Komakuk 29 June 1975.

CLIFF SWALLOW. *Petrochelidon pyrrhonota*. R(sr?). Repeated observations in the vicinity of Cache Creek and Babbage River suggest that Cliff Swallows probably nest in the area. Locality records: Cache Creek (two on 9 June 1974; two on 19 June 1971; six on 5 July 1974; one on 23 July 1971); Babbage River area (6 and 30 at upper Babbage River, 7 and 8 June 1973; present at lower Babbage River, 11–14 June 1974; three at Trail River, near junction with Babbage River, 13 June 1972). All localities had suitable nest cliffs nearby. Only coastal record one at Clarence Lagoon 14 June 1975.

COMMON RAVEN. *Corvus corax*. FCpr. Ravens foraged over a variety of habitats throughout the region, including the coastline and garbage dumps at DEW sites, but usually no more than one or two were present in an area. Only nest found (cliff adjacent to upper Babbage River) contained three young when discovered 1 June 1973; two nestlings and a recently fledged bird still present 20 June. Observations of ravens carrying sticks up into the steel girders of a communications tower at Komakuk in 1975 suggested attempted nesting, but no further evidence of breeding at this site was obtained. Twelve present at Komakuk and others seen along river courses in January 1975.

DIPPER. *Cinclus mexicanus*. VRv. One at open spring in Babbage River, 22 October 1975.

AMERICAN ROBIN. *Turdus migratorius*. R(sr?). Consistently observed during our brief visits to Cache Creek in both June (1971, 1973, 1974) and July (1971, 1974); at least one adult and one fledgling present at this location 23 July 1971. Two or more pair were resident in tall brush at upper Babbage River in 1973 (first noted 20 May). Evidence of breeding limited to the fledgling noted above and to an old nest found at upper Babbage River 7 June 1973. The only other locality where robins were observed was Blow River (10 June 1974); the paucity of records suggests a discontinuous distribution related to availability of tall brush habitat.

VARIED THRUSH. *Ixoreus naevius*. R(sr?). Observed only at upper Babbage River, where at least two pairs were resident in tall brush from 1 June 1973. Singing males were heard throughout early June but no other evidence of breeding was obtained.

SWAINSON'S THRUSH. *Catharus ustulatus.* VRv. One male at Cache Creek, 9 June 1974.

GRAY-CHEEKED THRUSH. *Catharus minimus.* U(sr?). Recorded at Cache Creek, lower Babbage River, Trail River, and upper Babbage River during June; at the last site five or six singing males were present in a small area of tall brush in 1973 (first noted 3 June), although no nests were found. Latest record one at Cache Creek 23 July 1971.

WHEATEAR. *Oenanthe oenanthe.* Rsr. A pair of birds and a nest-hole containing seven eggs found on a ridge above Cache Creek 19 June 1971; on 23 July three fledglings observed same area. Other records for Cache Creek were one pair 9 June 1974, one bird 21 June 1973, and one pair (with the female carrying insects) 5 July 1974. These records suggest that Wheatears regularly nested in the Cache Creek area. May also have nested at upper Babbage River, where pairs noted on a ridgetop 4 and 8 June 1973.

BLUETHROAT. *Luscinia svecica.* VRv. Singing male in tall brush bordering a small lake, upper Babbage River, 9 June 1973. This was the first Canadian record of this species (Taylor et al. 1974).

YELLOW WAGTAIL. *Motacilla flava.* Usr (2 June–25 July). Observed each year at two or more locations between Cache Creek and Clarence Lagoon. Locally numerous in tall brush habitat along Firth River and lower Babbage River in 1972, with six or more pairs present near the latter site. On 24 June 1972 a nest with five eggs was found in tussock-heath tundra near the river bank at lower Babbage River; this was the first Canadian nesting record (Black 1972), although three or four flying immatures had been observed 23 July 1971 at Cache Creek.

WATER PIPIT. *Anthus spinoletta.* U(sr?) (10 May–29 September). Observed at scattered locations across the area (Cache Creek, upper Babbage River, Crow River, Herschel Island, Firth River, Komakuk, Clarence Lagoon) but usually no more than a few were seen at each site. Three pair that frequented a ridge near upper Babbage River May–June 1973 may have been nesting; an observation of an adult carrying insects at Cache Creek 5 July 1974 also suggested nesting activity.

RED-THROATED PIPIT. *Anthus cervinus.* VRv. A single bird identified as this species was observed briefly when it landed in tussock-heath tundra at upper Babbage River, 9 June 1973. Field marks noted by two observers were a pinkish throat, light legs, and a black streaked necklace. The Red-throated Pipit has not been previously recorded in Canada, although it is fairly common in western Alaska and has occurred once at Point Barrow (Kessel and Gibson 1978).

BOHEMIAN WAXWING. *Bombycilla garrulus.* VRv. Recorded only at upper Babbage River (four flying NE, 5 June 1973).

NORTHERN SHRIKE. *Lanius excubitor.* VRv. Singles at Bloomfield Lake (14 September 1973) and Blow River (16 September 1973).

SOLITARY VIREO. *Vireo solitarius.* VRv. One at Bloomfield Lake 21 September 1973, feeding among low willows.

YELLOW WARBLER. *Dendroica petechia.* Usr (27 May–26 July). Recorded at scattered locations between Cache Creek and Firth River, breeding at Cache Creek (one nest with two eggs and three nestlings 5 July 1974) and at upper Babbage River (freshly constructed nest 8 June, with five eggs 25 June 1973). An observation of a singing male along Crow River, 15 June 1975 also suggested breeding activity. All records in tall brush habitat.

YELLOW-RUMPED WARBLER. *Dendroica coronata.* VRv. One (Myrtle) at lower Babbage River, 1 June 1972.

BACKPOLL WARBLER. *Dendroica striata.* VRv. Two records: one male in tall brush near lakeshore at upper Babbage River, 5 June 1973; one at Shingle Point in September 1973.

NORTHERN WATERTHRUSH. *Seiurus noveboracensis.* VR(sr?). Records limited to two singing males in tall brush habitat along upper Babbage River, 7 June 1973, and one singing male at Cache Creek, 9 June 1974.

WILSON'S WARBLER. *Wilsonia pusilla.* VR(sr?). Observed only at Cache Creek (one male 9 June 1974, two males 18 June 1971), at upper Babbage River (one male 10 June 1973), and along Crow River (one male 15 June 1975), all in tall brush habitat.

RUSTY BLACKBIRD. *Euphagus carolinus.* VRv. Observed along Trail River (two on 1 June 1972), at Komakuk (one remaining in vicinity, 10–23 September 1973), and at Shingle Point (one on 18 September 1973).

HOARY/COMMON REDPOLL. *Carduelis hornemanni/C. flammea.* Asr (26 May–28 September). Observed throughout the area during breeding season. Both Common and Hoary Redpolls were identified (but see Pitelka 1974); the Common:Hoary ratio was estimated to be ~3:1. Redpolls were most often found in association with tall brush, which also constituted nesting habitat; nests also were found in driftwood piles along the coast. Only one clutch followed to completion (four eggs), but 2 five-egg clutches also found.

SAVANNAH SPARROW. *Passerculus sandwichensis.* Csr (26 May–24 September). Widely distributed inland and (less commonly) along the coast. Dwarf shrub habitat was utilized for nesting; completed clutch size of six nests averaged 5.3 (range 5–6). Breeding density was estimated at 2.9 territories/km^2 at lower Babbage River (1972) and 19.9 territories/km^2 at upper Babbage River (1973).

DARK-EYED JUNCO. *Junco hyemalis.* VRv. Recorded only at Cache Creek (one on 9 June 1974), at Blow River (one on 12 September 1973), and at Komakuk (one on 10 September 1973; one found dead 21 May 1975); all were the Slate-colored form.

TREE SPARROW. *Spizella arborea.* Asr (28 May–14 September). Nested at several inland locations and probably in suitable habitat north to the coast (one fledgling 30 July 1971 at Phillips Bay; one male singing from power pole at Komakuk 21 June 1975). Preferred habitat, as determined from transect data, was tall brush, but most nests were in dwarf shrub habitat. Although at least seven nests were found, only two were followed to completion (each completed clutch five eggs).

WHITE-CROWNED SPARROW. *Zonotrichia leucophrys.* Usr (26 May–24 September). Widely distributed between Cache Creek and Firth River, in association with tall brush. A nest

found in this habitat at upper Babbage River contained four eggs 7 June 1973; no other nests were found but fledglings were observed at scattered locations within the above range. The only coastal record is of one at Komakuk 28 and 29 May 1975.

FOX SPARROW. *Passerella iliaca.* Usr (26 May–26 July). Observed at inland locations from Cache Creek to Firth River, in association with tall brush habitat. In 1973 this species was present at upper Babbage River by late May; a nest in tall brush contained four eggs 7 June and four young 20 June. The only other evidence of breeding was at Cache Creek (one fledgling 23 July 1971).

LINCOLN'S SPARROW. *Melospiza lincolnii.* VRv. One observed at close range 14 June 1975 at Clarence Lagoon.

LAPLAND LONGSPUR. *Calcarius lapponicus.* Asr (9 May–23 September). Longspurs were found throughout the area and were by far the most abundant passerine on the Coastal Plain. Spring arrival coincided approximately with snow melt. In 1975, males arrived first (first recorded at Komakuk 9 May) followed by females 3 wk later (first recorded at Komakuk 29 May). Territorial singing was first noted late May and peaked during first 2 wk of June. Territorial densities derived from plots in predominantly tussock-heath tundra were 95/km^2 (lower Babbage River 1972), 81/km^2 (Firth River 1972), and 141/km^2 (upper Babbage River 1973). Longspurs were found in a variety of habitats, but nest data indicate that females preferred to nest in tussock-heath tundra. A distinct preference for nest sites with southerly exposures beneath *Eriophorum* tussocks was found at Firth River and lower Babbage River in 1972. Completed clutch size of 86 nests found during 1972–1973 averaged 5.3 eggs (range 4–7). Fledging occurred late June – early July. Premigratory flocks sometimes numbering 50 or more birds formed after fledging; most longspurs had left the area by late August but a few were recorded well into September.

SNOW BUNTING. *Plectrophenax nivalis.* FCsr (19 April–28 September). Observations confined largely to coastal areas, except for a few inland records during spring and fall migration. Spring migrants arrived somewhat earlier than indicated above; one was recorded by a DEW-site employee at Komakuk 10 April 1975. Snow Buntings were the most numerous breeding passerine in some coastal areas. Fifteen nests were found, in association with piles of driftwood along the coast, abandoned buildings, or old oil drums. Maximum clutch size was seven, but nest data were incomplete. In 1975, when most nests were found, eggs were present 12 June–9 July, the first hatched young were recorded 3 July, and the first evidence of fledging was obtained 7 July. Family groups observed at Nunaluk Spit from mid-July 1972 began migrating in August; a major movement E occurred 14–17 September. Late records include 50 at Blow River 18 September 1973, 13 at Shingle Point 25 September 1973, 100 at Bloomfield Lake 28 September 1973, and 285 at Komakuk 28 September 1973.

Discussion

In terms of physiography, habitats, and avifaunal composition, the study area is an eastward extension of the much larger Coastal Plain of Arctic Alaska. Differences from the Alaskan avifauna appear to be due primarily to geographic rather than ecological factors, namely distance from the Chukchi Sea and the Asiatic coast on the west. Thus, many of the species recorded for the Barrow region (Pitelka 1974), but not on our study area, are Asiatic, Beringian, or maritime stragglers confined largely to the western end of the Coastal Plain. Of the 151 species listed for Barrow we failed to record only 2 of 22 regular breeders (Steller's Eider, *Polysticta stelleri*; Western Sandpiper, *Calidris mauri*), 2 of 13 irregular breeders (Spectacled Eider, *Somateria fischeri*; Curlew Sandpiper, *Calidris ferruginea*), 1 of 9 migrants (Ross' Gull, *Rhodostethia rosea*), and 3 of 21 infrequent visitors (Bar-tailed Godwit, *Limosa lapponica* Rufous-necked Sandpiper, *Calidris ruficollis*; Arctic Warbler, *Phylloscopus borealis*), but we did not see 13 of 14 maritime visitors or stragglers, 26 of 55 North American stragglers, or any of 12 Asiatic stragglers. These differences are not as apparent if we compare our study area with the central part of the Arctic Coastal Plain. Of 72 species recorded by Sage (1974) in the Atigun and Sagavanirktok valleys, we failed to record only Wandering Tattler (*Heteroscelus incanus*), Western Sandpiper, Bar-tailed Godwit, Black-billed Magpie (*Pica pica*), Arctic Warbler, and Smith's Longspur (*Calcarius pictus*). Most of these species were found by Sage in mountains or foothills, physiographic provinces not covered in this paper. Only two species additional to those we found on the Canadian Coastal Plain (Spectacled Eider, Dotterel, *Eudromias morinellus*) were listed by Andersson (1973) for Nuvagapak Point, near the Alaska-Yukon border. Conversely, we found a few species that have not been recorded on the Alaskan Coastal Plain (Canvasback, Iceland Gull, Little Gull, Bohemian Waxwing, and Solitary Vireo); all were very rare visitants to the study area.

Of the 122 species that we recorded, only four (Gyrfalcon, Willow Ptarmigan, Snowy Owl, Common Raven) were found to be permanent residents. A few others (e.g., Rock Ptarmigan, Dipper) may have been present in winter but were not recorded during our brief winter visits. Three permanent residents (all but Snowy Owl) and 43 summer residents were found nesting or with flightless young (possibly 45 if both Lesser and Greater Scaup and Common and Hoary Redpolls nested in the area); indirect evidence of breeding was found for an additional 14 species. Our observations extend the known breeding ranges (beyond those shown by Godfrey 1966) of Brant, Mallard, Pintail, American Wigeon, Northern Shoveler, scaup (possibly both species), Pectoral Sandpiper, Stilt Sandpiper, Buff-breasted Sandpiper, Red Phalarope, Black Guillemot (but see Kuyt et al. 1976 who

summarize both previous and subsequent records), Say's Phoebe, Yellow Wagtail, Yellow Warbler, White-crowned Sparrow, and Fox Sparrow, and possibly of Common Snipe, Spotted Sandpiper, Least Sandpiper, Long-billed Dowitcher, Cliff Swallow, American Robin, Varied Thrush, Gray-cheeked Thrush, Northern Waterthrush, Wilson's Warbler, and Hoary Redpoll. Conversely, Godfrey showed Yellow-billed Loon, White-fronted Goose, Harlequin Duck, King Eider, White-winged Scoter, Surf Scoter, Sandhill Crane, Dunlin, Snowy Owl, and Smith's Longspur as breeding within the area. We did not find nests or evidence of nesting for any of these species during our studies, although Harlequin Ducks likely nested in the adjacent foothills area and Snowy Owls almost certainly nest on the Coastal Plain in some years.

In addition to supporting a large and varied breeding avifauna, the study area is important for migration, molting, and staging of various species. Our studies showed the coastline to be a major migration corridor, both for species that migrate east in spring and/or west in fall (presumably around or across Alaska: loons, Brant, Oldsquaw, Common Eider, White-winged and Surf Scoters, Baird's Sandpiper, Sanderling, Stilt Sandpiper, Red Phalarope, Pomarine Jaeger, Glaucous Gull, Arctic Tern, Short-eared Owl) and for species that migrate west in spring and/or east in fall (presumably through interior North America: Whistling Swan, Canada Goose, White-fronted Goose, Pintail, Sandhill Crane, American Golden Plover, Pectoral Sandpiper, Long-billed Dowitcher, Northern Phalarope, Snow Bunting). A number of waterfowl species (primarily Oldsquaw and Surf Scoter, but also scaup, Common Goldeneye, Harlequin Duck, Common Eider, White-winged Scoter, and Red-breasted Merganser) utilized sheltered coastal waters, especially near Herschel Island, for molting. The western Canadian population of Snow Geese made extensive use of inland tundra habitat for autumn pre-migratory staging. Although geese also dispersed into Alaska at this time, the Canadian portion of the Coastal Plain was the most important staging area.

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Extralimital Records of White Whales (*Delphinapterus leucas*) in Eastern North American Waters

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Reeves, Randall R. and Steven K. Katona. 1980. Extralimital records of White Whales (*Delphinapterus leucas*) in eastern North American waters. Canadian Field-Naturalist 94(3): 239–247.

Published "extralimital" records of white whales (*Delphinapterus leucas*) in the Canadian Maritimes and the northeastern USA were reviewed, and new unpublished observations were considered. The species now definitely can be reported from as far south as coastal waters of New Jersey (38°55′N). White Whales may have had a wider, somewhat more southerly distribution in the northwest Atlantic prior to European settlement, but we suspect that factors such as thermoregulatory stress, predation, competitive exclusion, and possibly aboriginal hunting discouraged establishment of viable breeding stocks south of Cabot Strait. White Whales seen in the waters of the Canadian Maritimes and New England states are probably emigrants from the St. Lawrence population, which consists of several hundred individuals.

Key Words: White Whale, Beluga, *Delphinapterus leucas*, straying, extralimital occurrence, Nova Scotia, New Brunswick, New England, geographical distribution.

In their review of White Whale or Beluga (*Delphinapterus leucas*) populations in North America, Sergeant and Brodie (1975) recounted evidence for occasional straying by individuals of this cold-adapted species from arctic or subarctic to cold temperate latitudes. They suggested, for instance, that an animal seen in Buzzards Bay, Massachusetts, USA, in spring of 1972 may have come from the St. Lawrence Estuary, where an isolated population of several hundred resides. Sergeant and Brodie (1969) and Sergeant et al. (1970) had suggested earlier that some St. Lawrence animals use the Gaspé Current to clear Cape Breton Island, then follow the cold Labrador Current along the coast of Nova Scotia, occasionally reaching the Bay of Fundy in spring. Some must continue along the New England coast, as evidenced by the Buzzards Bay individual and others known to have reached the coasts of Maine (Norton 1930; Mairs and Scattergood 1958) and Massachusetts (Goode 1884; Townsend 1929). Several new records implying even more dramatic straying by White Whales have come to our attention and are reported here.

There are at least two species with which Belugas are likely to be confused, and for this reason it is necessary to apply a certain degree of skepticism to reports not substantiated with photographic evidence or specimen material. Adult Risso's Dolphins (*Grampus griseus*) are usually mostly white or light gray except for the dorsal fin and flippers, and they fall within the Beluga's size range. Though in some ways superficially similar in appearance, the two species should be readily distinguished by the prominent, dolphin-like dorsal fin of Risso's Dolphin in contrast to the Beluga's complete lack of a dorsal fin. The only other small whale without a dorsal fin in the western North Atlantic is the Narwhal (*Monodon monoceros*), whose distribution is even more polar than the Beluga's. No Narwhal records exist for the east coast of North America south of Newfoundland (Reeves and Tracey 1980).

Recent New Jersey and Long Island Occurrences

On 17 July 1978 two Belugas, one white adult (about 4 m long) and one gray juvenile (about 3 m long; see Figure 1), were seen by two divers a few kilometres off Avalon, New Jersey (Ulmer 1979). The larger individual was unapproachable, but the young one was apparently attracted to people in the water. According to Robert Schoelkopf (personal communication), Director of the Marine Mammal Stranding Center in Atlantic City, the larger animal disappeared after several days, but the younger individual remained in the area for about 2 wk. Attempts to capture it with a view toward relocating it to Nova Scotian waters were unsuccessful, although at times it showed considerable interest in boats and allowed close approach. Additional sightings, apparently of the same young animal, were made through mid-August in the vicinity of Townsend's Inlet. One of these is documented in a newsphoto apparently taken on 9 August (*Philadelphia Inquirer*, 10 August 1978, p. 1).

A subsequent encounter with what was probably the same juvenile Beluga took place in September 1978, between Hereford Inlet, New Jersey, and Cape May Inlet (M. D. Sprague, United States Coast Guard Air Station, Cape May, personal communication). This sighting is documented in photographs seen by us. Part of Mr. Sprague's account is quoted below:

FIGURE 1. Young Beluga seen in inshore waters of southern New Jersey, near Cape May, July–September 1978. Photo by Mike Horn.

> The whale seemed to be attracted by the sounds of the boats' engines, in particular the 40′ USCG patrol boat we were on. She actually seemed to be playing with us — several times she swam directly underneath us, turning upside down and cruising inverted along the surface until in need of air.

In early March of the following year (1979) a young Beluga, estimated length 3 m, was "escorted" by Coast Guard personnel through Jones Beach Inlet, Great South Bay, Long Island, New York (Jay Hyman, Larchmont, New York, personal communication). This individual (see Figure 2) reportedly approached vessels and rubbed against working nets, allowing close observation. Jay Anderson (personal communication), a fisherman from Sayville, New York, saw this animal regularly for about 1 mo (March through April) near buoys 15, 16, and 17 in the East Channel of Great South Bay. It followed his boat as he raked clams. While the clam rake was being picked up, the Beluga followed it. It also "rooted" along the bottom after the clâm rake went past and was seen to eat spider crabs (probably *Libinia* sp.). Anderson provided an excellent sketch of the Beluga and noted that it had markings or scars as follows: a horizontal scar on the right side midway between flippers and flukes; a vertical scar on the left side running from back to chest, just aft of the flipper; and an arrow-like mark on the left side below the hump of the back. We have attempted to match scarring patterns shown in photos of the New Jersey and Long Island whale(s) (see Figures 1 and 2). Although there is evidence of large scarred patches in most of the pictures, we are unable to determine conclusively that the same individual has been involved in all the sightings.

FIGURE 2. Young Beluga seen in Great South Bay, Long Island, March–July 1979. Photo by Frank Keating, *Newsday*.

The behavior described for the Great South Bay animal(s) was strikingly similar to that described for the New Jersey Beluga, and it is tempting to speculate that the same individual survived the winter and reappeared inshore in spring, perhaps following spawning fish. Sighting reports for the Jones Beach area continued through spring and summer, some of them documented by photos. A Beluga was seen by fishermen in this area as late as mid-October 1979 (F. Keating, *Newsday*, Long Island, New York, personal communication). The sedentary behavior of the New Jersey and Long Island Beluga(s) is reminiscent of Sergeant's (1978) observations made in a small basin near the coast of Newfoundland, where a "stray" adult Beluga remained for an entire summer and fall. As he put it: "The unwillingness of this animal to explore its environment is remarkable; its semi-enclosed location evidently gave it some form of security."

Several authors, among them Fisher and Sergeant (1954) and Mercer (1973), have written that White Whales are distributed south to New Jersey, basing their statements on Anderson's (1946) designation of Atlantic City as the southern limit of the species' known occurrence along this coast. Anderson's report apparently stemmed from a misreading of True (1910), in which a description is given of two White Whales held in a tank at Atlantic City in 1908. True did not make clear where the whales had been captured, although it would have been reasonable to assume that, like many of their species taken for captive display since at least as early as 1861 (Wyman 1863; Lee 1878), they were caught and transported from subarctic waters of eastern Canada. One of us (Reeves) examined the skull of one of these two captive individuals, which is catalogued as USNM 238104 in the Smithsonian Institution. Although the label tied to the specimen says "from Atlantic City," museum curatorial records show that the whale actually was collected in the St. Lawrence River by A. Minor Renshaw.

FIGURE 3. Beluga trapped in herring weir off Bliss Island, Back Bay, New Brunswick, 24 June 1976. Photo by W. B. Scott.

Connor (1971) described a small whale seen in outer Long Island Sound in June 1942 as a Beluga, and an informant of his noted that fishermen had reported seeing White Whales at other times. In the absence of photos or a specimen, however, such records must remain suspect, particularly in view of the frequent occurrence of Risso's Dolphin in the deep-water fishing grounds off New York.

The "extralimital" distribution of White Whales can now be definitely extended to waters of Long Island and southern New Jersey. The well documented occurrences reported in this paper lend credence to Connor's (1971) account as well as to others from farther north along the coast, recorded as "probable" in Table 1.

Mortality in Weirs

An interesting aspect of records of White Whales outside the St. Lawrence system is the proportion in which fishing weirs were implicated in their capture. Fisher and Sergeant (1954) described the capture of one individual in a weir near the coast of New Brunswick, and Goode (1884) mentioned a cow and calf caught in a Massachusetts weir. We can add two more incidents to the literature, one involving probably a Beluga trapped in a weir off Cape Cod in 1916 (Falmouth, Massachusetts, *Enterprise*, 16 May 1947, p. 2-B) and the other a 3- to 4-m individual taken in a herring weir near Passamaquoddy Bay, New Brunswick, in 1976 (W. B. Scott, Huntsman Marine Laboratory, St. Andrews, New Brunswick, personal communication; see Figure 3). At least three of these four records are for the month of June, when fishermen traditionally make large catches of Atlantic Herring (*Clupea harengus harengus*) which are then inshore in dense schools. These records suggest that the Belugas might also have been chasing herring.

Zoogeographic Implications

The records mentioned in this paper raise two questions: (1) why aren't there more Belugas south of the Arctic and, in particular, south of the St. Lawrence River; and (2) why are there so many "stray" animals? The factors influencing cetacean distribution are obscure, but they probably include temperature, predator avoidance, feeding strategy (including competition), and food abundance. Sergeant and Brodie (1969), Brodie (1975), and Sergeant (1978) have given these questions thoughtful attention, and we elaborate on some of their arguments below.

Temperature

The temperature tolerance of Belugas must be rather wide, because they are known to move from near-freezing sea water in broken pack ice into warm

TABLE I—Extralimital records of White Whales in waters of southeastern Canada and the eastern United States

Date	No. animals	Location and comments	Source
Before 1675	"some" (probable)	"in Black-point Harbour, & some way up the river" (vicinity of Plymouth, Massachusetts)	Josselyn 1675
18th century	one	Outer Cape Cod	Waters and Rivard 1962
19th century (?)	one	Stranded in Digby Basin	Gilpin 1878
About 1857	one	Killed in Provincetown Harbor, Cape Cod, Mass., 3.8–4.5 m	Goode 1884
11 October 1875	two	Killed in weir in Yarmouth River, Cape Cod, Mass. adult female and calf	Goode 1884
1875 or 1876	one (probable)	Seen in Provincetown Harbor, Cape Cod, Mass.	Goode 1884
July 1892 or 1893	one	Merryconeag Sound, Maine	Norton 1930
Late July 1904	one	Near Breakwater Light, Portland Harbor, Maine	Norton 1930
13 November 1904	one	Seen off Rockport, Cape Ann, Mass.	Townsend 1929
November 1906	one	Seen at mouth of Kennebec River, Pond Island Bar, Jacknife Ledge, Maine	Norton 1930
Summer 1907	one	Mackerel Cove, Baileys Is., Maine; escaped attempts to capture it	Norton 1930
June 1916	one (probable)	Killed in weir off Brewster, Cape Cod, Mass.	Falmouth (Mass.), *Enterprise*, 16 May 1947, p. 2-B
September 1916	one	Seen in Portland Harbor, Maine	Norton 1930
1 August–25 September 1927	six	Seen for two months in Portland Harbor and between Orr's Is. on east and Wood Is. on west, Maine; usually seen together; creamy white, no dorsal fin	Norton 1930
30 August 1927	three–four	Fisherman attempted to harpoon in Diamond Island Roads, Casco Bay, Maine	Mairs and Scattergood 1958
23–28 January 1928	two	Seen near Black's Cove, Great Chebeague, Maine	Norton 1930
8 June 1928	two	Seen between mouths of Essex and Ipswich rivers, Mass., adults	Townsend 1929
June 1942	one (probable)	Off Orient, Long Island Sound, New York, 3–4 m	Connor 1971
12 June 1952	one	Caught in herring weir, Maces Bay, Charlotte Co., New Brunswick, adult female; specimen	Fisher and Sergeant 1954
Summer 1953	one	Seen "from time to time" in Bay of Fundy	Fisher and Sergeant 1954
30 April 1954	one (two?)	Seen in Penobscot River, Bangor, Maine	Mairs and Scattergood 1958
Early May 1965	one	Killed at Fox Point, St. Margaret's Bay, Nova Scotia, adult, 4.5 m; specimen	Sergeant et al. 1970
Late May 1968	one	Killed in Bedford Basin, Halifax, Nova Scotia	Sergeant et al. 1970
Spring 1972	one	Seen in Buzzards Bay, Mass.	Sergeant and Brodie 1975
29 September 1974	one	Seen in Somes Sound, Maine	Katona, unpublished data
1–18 June 1976	one (probable)	Seen at Brewster and Green Is., Mass. (June 1); Swampscott, Mass. (June 7); Beverly, Mass. (June 4); Marblehead, Mass. (June 7, 18); length variously estimated as 3–6 m; could have been two individuals	John Prescott, personal communication, reported to New England Aquarium
24 June 1976	one	Caught in herring weir off Bliss Island, Back Bay, New Brunswick; 3–4 m; photos and specimen	W. B. Scott, personal communication, reported to Huntsman Marine Laboratory
20 March 1978	one (probable)	Seen near Rockport, Mass., about 5 m	John Prescott, personal communication, reported to NEA
9 April 1978	one (probable)	Seen off Hadley Pt., Salisbury Cove, Mt. Desert Is., Maine	Katona, unpublished data
18 July–September 1978	two	Seen between Townsend's Inlet and Cape May, New Jersey; adult and juvenile; photos	Ulmer 1979; this account
March–July 1979	one (plus?)	Seen in and near Great South Bay, Long Island, New York; photos	This account

(12–18°C) estuarine water within the span of less than 1 h (Brodie 1975). Surface temperatures in coastal New Jersey rarely exceed 13°C, except in high summer when a maximum average of 22.5°C is reached in August (Schroeder 1966). It is unlikely that temperature alone excludes Belugas from coastal waters as far south as New Jersey, except perhaps during the warmer late summer months or in unseasonably warm years. Our understanding of Beluga energetics, however, is not advanced enough to allow definitive comment on this subject.

Predator Avoidance

Little is known about effects of predation on cetaceans. Killer Whales (*Orcinus orca*) and polar bears (*Ursus maritimus*) are the only known predators of Belugas (Vladykov 1944; Freeman 1973), although much of the evidence for such predation is circumstantial or hearsay. Sergeant and Brodie (1969) suggested that Killer Whale predation might be a factor limiting White Whales to the Arctic. They pointed out that Belugas move away from shallow estuaries and penetrate oceanic and more southerly waters primarily in winter, when the Killer Whales are driven away from high latitudes by ice. A large proportion of the Beluga records cited here are for the period spring through fall (Table 1), at least partly because good weather and human observers are more common in those seasons. Killer Whales appear, in our experience and judging by statements in literature (*reviewed by* Backus 1961), to be relatively scarce inshore south of Nova Scotia at any time of year. Strandings have occurred in mid-winter, and we have received verbal reports of small pods visiting in late summer and fall, coincident with an influx of baleen whales and large fish schools. Because both Killer Whales and Belugas are more abundant inshore north of Nova Scotia than they are from Nova Scotia south (Sergeant and Fisher 1957), and because they both are found during the same part of the year south of Nova Scotia, it is unlikely that Killer Whales alone prevent Belugas from extending their range southward.

At the same time, we think it worth considering the possibility that shark predation helps define the southern limit of Beluga distribution. Large predatory sharks (especially the White Shark, *Carcharodon carcharias*) definitely occur in the Gulf of Maine and lower Bay of Fundy (Bigelow and Schroeder 1948; Day and Fisher 1954; Templeman 1963), and probably in greater density than Killer Whales. Arnold (1972) found enough evidence to conclude that White Sharks are "a potentially significant predator of Harbour Porpoises (*Phocoena phocoena*) in the Canadian Atlantic." If, as Sergeant and Brodie (1969) asserted, Belugas possess "inferior muscular development, as compared with a delphinid," perhaps they would be no better able than even the small, but quick and active Harbor Porpoise to escape from large sharks. According to Boulva and McLaren (1979), sharks are probably the most important predators on seals in Eastern Canada. Predation pressure from sharks would tend to displace Belugas northward, because sharks are more common in southern waters. We should emphasize that we have no evidence to indicate that sharks attack White Whales.

Feeding Strategy (Competition)

Sergeant and Brodie (1969) and Sergeant (1978) implicated competition from the Harbor Porpoise as an important factor in the exclusion of Belugas from the Bay of Fundy. We agree that competition may be a major barrier to their southward distribution, but we suspect that additional species interactions may be involved. Starting in April or May, coastal portions of the Bay of Fundy – Gulf of Maine region host large schools of Atlantic Herring, Atlantic Mackerel (*Scomber scombrus*), Short-finned Squid (*Illex illecebrosus*), euphausiids (*Meganyctiphanes norvegica*), and other prey species, and a variety of marine mammals come to feed on them. Unfortunately, we have no empirical grounds for assuming that Belugas and other local marine mammals are food limited, so the following comments about trophic dynamics are little more than informed speculation (see Estes 1979 for a discussion of the difficulties of studying marine food chains). Competitive exclusion between species might as easily turn on the question of how "whale space" (Mitchell 1979) is to be allocated as on the matter of how limited food resources are to be apportioned.

At least five or six species are potentially significant competitors for Belugas: Harbor Porpoises, Atlantic White-sided Dolphins (*Lagenorhynchus acutus*), White-beaked Dolphins (*Lagenorhynchus albirostris*), Harbor Seals (*Phoca vitulina*), Gray Seals (*Halichoerus grypus*), and possibly Long-finned Pilot Whales (*Globicephala melaena*). Although Belugas are catholic feeders, utilizing up to 100 different species (squids, crabs, shrimps, clams, snails, worms, and a variety of fishes; see Kleinenberg et al. 1969 for a summary), these other marine mammals are also using many of the food resources which Belugas could hunt in the midwater to 40-m depths where they feed. In the inshore areas and over nearshore banks, Harbor Porpoises eat mainly Atlantic Herring, Atlantic Cod (*Gadus morhua*), and Atlantic Mackerel, plus other fishes and some squids and invertebrates (Smith and Gaskin 1974). Harbor Seals feed on many of the same organisms as well as on various groundfishes in the waters surrounding their inshore haul-out ledges (Richardson et al. 1974; Boulva and McLaren 1979). Gray Seals, which are more numer-

ous in the Canadian Maritimes than in the Gulf of Maine, also feed opportunistically on herring, cod, squid, and bottomfish (Mansfield and Beck 1977). Farther offshore, the two *Lagenorhynchus* species probably dominate productive banks, concentrating on midwater fishes and squid, apparently with some dietary overlap, but with a tendency for *L. albirostris* to prefer cooler, more boreal water (Sergeant and Fisher 1957; Katona et al. 1976). Pilot Whales would also be important competitors for squid, usually in offshore regions (Mercer 1975). The establishment of Beluga populations south of Cape Cod is very likely discouraged by competition from Pilot Whales, Bottlenose Dolphins (*Tursiops truncatus*), and other small odontocetes, acting in conjunction with high summer water temperatures and some predation pressure from large sharks.

Food Abundance

We also should not overlook the potential importance of competition with humans for food and space. In southwestern Alaska Belugas are known to prey seasonally on salmon (*Oncorhynchus* spp.) smolt to such an extent that they are regarded as a major nuisance to fisheries there (Fish and Vania 1971). The Atlantic Salmon (*Salmo salar*) historically spawned in large river systems along the coast from Connecticut to the St. Lawrence River, including the Merrimack in New Hampshire, the Kennebec and Penobscot in Maine, the St. Croix and St. John in New Brunswick, and the Mersey in Nova Scotia (Netboy 1968). Industrial development and overfishing since the colonial period have caused the Atlantic Salmon to decline drastically in New England and the Maritimes, and its biomass today is a small fraction of that of the Pacific salmons. Vladykov (1946) demonstrated that only a small proportion of the White Whale's diet in the St. Lawrence consists of salmon, but the fact that some Alaskan Belugas depend heavily on salmon (*Oncorhynchus* spp.) suggests the possibility that salmon were once a significant seasonal food source for Belugas in the Atlantic south of Newfoundland. It may also be worth noting that other fish stocks in cold temperate waters of the eastern North American continental shelf have long been subjected to heavy fishing pressure (Christy and Scott 1965), making humans a potentially serious competitor with sea mammals there, including the Beluga. This factor alone is probably not sufficient to alter the Beluga's distribution, but if it were already at a competitive disadvantage with more southerly marine mammals, decreased food abundance could exacerbate that disadvantage.

Discussion

For the moment, the competition hypothesis appears to be the most compelling explanation for the Beluga's limited distribution. A dynamic interplay among the various factors discussed above, however, is probably at work. We are struck by the fact that, despite the morphological features (lack of a dorsal fin, thick skin and blubber layer, and white color) suggestive of adaptation to an arctic environment, healthy Belugas regularly appear outside the normal range of the species. We believe these occurrences are biologically meaningful; the animals may be something more than accidental strays.

Two factors may be relevant. First, long migrations are a normal part of Beluga behavior in some areas. They move far up rivers in many parts of their range, reaching distances of 500–2000 km from the sea in some cases (Kleinenberg et al. 1969). Interestingly enough, the coastal route from Cabot Strait to southern New England would cover about 2000 km. Evidence cited here suggests that individuals far from their usual range are able to eat a wide spectrum of food and survive for a long time. Probably most of these animals originate from the St. Lawrence River population. This population is excluded from much of its habitat in the St. Lawrence in winter owing to ice formation, although ice-free areas in the estuary do exist and are known to harbor some overwintering White Whales (Vladykov 1944). Perhaps some individuals passing the winter in the Gulf of St. Lawrence or along the open coasts of Labrador and Newfoundland wander southward in search of food. By breakup time in the St. Lawrence they are well on their way to new territory. It is of interest to note that no strandings of White Whales have been reported on the United States Atlantic coast. This suggests the possibility that stragglers, if unmolested, can survive whatever rigors are encountered in their wanderings. Since individuals can swim 2000 km upstream in rivers, there is little reason to doubt that they could swim equal distances against currents in the ocean, perhaps returning to the St. Lawrence area to breed.

Second, it is possible that the tendency to wander (or explore) is an adaptive trait in the Beluga's arctic habitat, where extreme seasonal and year-to-year weather and hydrographic fluctuations change the configuration of the coastline and the productivity of particular areas. Also, it is known that Belugas congregate (and probably give birth) in shallow water near the mouths of rivers in summer (Sergeant 1978). Although we do not yet know whether individuals tend to return to the same rivers year after year, it would seem that a certain amount of wandering by some individuals would be useful to facilitate outbreeding.

It is not unreasonable to wonder whether Belugas were once more common south of Cabot Strait than they are now. Small populations could have estab-

lished themselves in conjunction with climate changes or changes in the populations of competitors. It is possible that early hunters extirpated such Beluga populations before the arrival of people who would have left a written record of their presence. For example, the Red Paint Indians, who inhabited Maine and the Canadian Maritimes beginning at least 5000 yr ago and lasting until around 1500 B.C., are thought to have harpooned swordfish, porpoises, and small whales regularly during summer, perhaps from dugout canoes (Snow 1974). Mic Mac Indians in Nova Scotia are said to have killed "white whales" from time to time using rifles during the mid- to late 1800s, although Harbour Porpoises were their main prey (Leighton 1937), and 'a superstitious dread' of White Whales prevented some hunters from attacking them (Gilpin 1878). Surely Belugas would have been easy prey for skilled hunters; and small, local populations could have been killed off very quickly. No Beluga bones are known to have been found, however, among the marine mammal remains discovered in Gulf of Maine kitchen middens left by prehistoric Indians (Loomis and Young 1912; Waters 1967).

The records of Beluga distribution discussed above and listed in Table 1 have stimulated us to view these animals as a small but normal component of our boreal marine mammal fauna. It seems prudent to think of the occasional Belugas found south of Cabot Strait not as "strays," but as "wanderers" or "explorers," which have the potential to survive far from their normal range and perhaps occasionally to return. Elton's (1956) philosophical reflection on animal distribution has been very helpful to us in thinking about this phenomenon:

> The exact limits of the ranges of a number of animals are constantly shifting backwards and forwards, ebbing and flowing as the conditions change, and as the numbers of each species increase or decrease. We understand at present little about the precise causes of these fluctuations in range; but although the immediate influence at work may often be biotic, many of these changes are no doubt ultimately referable to short-period climatic pulsations, whether irregular or regular.

A detailed analysis of ice conditions and temperature cycles in the St. Lawrence region, viewed in conjunction with Beluga records from Nova Scotia, New Brunswick, and the northeastern United States, could be revealing.

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Halophytic Plants in Southern Ontario

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Catling, P. M. and S. M. McKay. 1980. Halophytic plants in southern Ontario. Canadian Field-Naturalist 94(3): 248–258.

Thirty-six salt-tolerant plant species are reported for southern Ontario and soil pH and Na levels are given for many of them. *Najas minor, Poa arida, Suaeda calceoliformis, Spergularia media, Centaurium pulchellum, Solidago sempervirens, Aster subulatus, Pluchea purpurescens* var. *succulenta* and the algae *Enteromorpha intestinalis* and *Enteromorpha prolifera* are reported for the first time from southern Ontario. The Ontario ranges of *Carex praegracilis, Juncus compressus, Juncus gerardii,* and *Spergularia marina* are significantly extended. Thirty less tolerant species found in soils with abnormally high Na are also listed. Certain plants may avoid salt by strategic timing of germination and growth. Most southern Ontario halophytes appear to be recent introductions from alkaline habitats to the west or from the eastern coastal salt marshes. Halophytic species are naturally spreading along highways in response to the use of de-icing salt and in many areas halophytes constitute a major portion of the vegetation cover.

Key Words: halophytes, plants, sodium, salt, pH, highways, vegetation cover, ecology, taxonomy, southern Ontario, Great Lakes region, Canada, *Najas minor, Poa arida, Suaeda calceoliformis, Spergularia media, Centaurium pulchellum, Solidago sempervirens, Aster subulatus, Pluchea purpurescens* var. *succulenta, Enteromorpha intestinalis, Enteromorpha prolifera.*

The occurrence of halophytic plants in southern Ontario has not been systematically documented. These plants represent an interesting part of the flora both from an ecological and economic viewpoint. In the following pages we provide locations, status, and soil pH and Na levels of southern Ontario halophytes, as well as notes on the taxonomy and ecology of some species.

Methods

The compilation of a complete list of halophytic plants in southern Ontario was undertaken from 1973 to 1979. It is based on examination of herbaria including the National Museum of Canada in Ottawa (CAN), the Biosystematics Research Institute, Agriculture Canada also in Ottawa (DAO), and the herbarium of the Department of Botany, University of Toronto (TRT), as well as various published lists and recent exploration of salt-rich habitats. Some or all of the herbaria (above) were provided with specimens to justify the new records resulting from recent exploration. Names of plants are taken from Scoggan (1978–1979) unless otherwise indicated.

Inclusion in the list is based largely on the generally accepted definition of halophytes, i.e., plants tolerant of 0.5% NaCl, which is equivalent to 5000 $\mu g/g$ NaCl or approximately 1960 $\mu g/g$ Na. Such levels exceed the usual Na levels in Ontario soils (5 to 43 $\mu g/g$) by at least 46 times (Ontario Department of Agriculture Soil Surveys and personal observations). Determinations of soil Na levels are provided where measured. Some species with relatively low soil Na values, or for which soil Na was not determined, are included on the basis of association with distinct halophytic species, likely exposure to relatively high Na levels periodically, and/or exposure to abnormally high soil pH.

Measurements of available (i.e., both water-soluble and exchangeable) soil Na were made by flame photometry of the elutant of ammonium acetate digestions of soil samples, using an EEL Mark II Flame Emission Photometer (Jackson 1958) and are expressed as micrograms per gram. Using this technique one is actually expressing weight of available Na in a weight of water equal to the dry weight of the soil. Because plant roots operate through a soil volume, expressing concentration on a volume basis may be desirable. To convert the $\mu g/g$ values to g/m^2 per 10-cm depth, multiply $\mu g/g$ by density/10. Although soil densities are not provided, they were normally about 1.0 g/cm^3 and varied relatively little (0.97 to 1.3 g/cm^3). Soil samples were collected from about the roots of plants from 2 to 10 cm deep. Although the volume determination does not take into account variations in Na concentration with depth and the exact soil density, it may still prove useful. Sodium levels in the soil are likely to vary depending on the time of year so that a plant may experience levels higher and/or lower than those reported here. Soil data presented here are based on samples collected in July and August.

Soil samples were prepared for pH determination by addition of a volume of distilled water approximately equal to the volume of the samples (about 50 mL). The sample was then stirred to a soupy consistency and pH was measured using a Beckman Zeromatic II pH meter. The term alkaline is used here to denote soils with relatively high pH (8.0 or higher). Such pH is usually associated with abnormally high

Na levels and these soils characteristically have poor permeability because of the dispersion of clay and organic material which accumulates in the soil pore spaces.

Salinity (i.e., the concentration of dissolved salts) reported for some water samples was measured using a refractometer (American Optical, temperature-compensated) with a salinity scale.

In order to prevent unnecessary repetition under several different species, the exact locations in Ontario of some especially productive alkaline habitats are provided below:

1) River Canard: alkaline ground near brine wells on both sides of Highway 18 south of the bridge over the Canard River, Sandwich West Township, Essex County, 42°10′N, 83°06′W.
2) Ojibway Salt Mine: northeast of the mine near to the Detroit River, Ojibway, Sandwich West Township, Essex County, 42°16′N, 83°06′W.
3) Windsor Salt Factory and nearby brine fields: to the east and west of Sandwich Street (Highway 18), both north and south of Prospect Avenue, and brine fields and pools on the west side of Matchette Avenue, City of Windsor, Sandwich West Township, Essex County, 42°17′N, 83°06′W.
4) Goderich: Sifto Salt brine works on the south bank of the Maitland River in the town of Goderich, Goderich Township, Huron County, 43°45′N, 81°43′W.
5) Amherstburg: open alkaline soil about a slowly running well, white salt crystals in some places, site of an old smelting factory, 2.4 km NE of Amherstburg, Anderdon Township, Essex County, 42°07′N, 83°05′W.

Annotated List

(1) Algal macrophytes

Enteromorpha intestinalis f. *maxima* and f. *cylindracea*

Both forms on wave-washed rocks in effluent stream and lagoon associated with the Ojibway Salt Mine, 23 August 1979, *P. M. Catling* (CAN, TRT). Not listed by Prescott (1951) or by Duthie and Socha (1976), this is apparently the first record in Ontario of this widespread alga of the sea coasts and of salt lakes in the western interior of North America. Muenscher (1927a, b) reported *E. intestinalis* with other halophytes from Wolf Creek below Silver Springs, Wyoming County, in western New York State. These halophytes were associated with waste from the Remington Salt Factory.

Enteromorpha prolifera

Quiet alkaline pool beside Windsor Salt Factory, 23 August 1979, *P. M. Catling* (CAN, TRT). Collins (1909) assigns this plant a wide North American distribution including the sea coasts, salt springs, and western salt lakes but we are unaware of any previous record from southern Ontario.

(2) Vascular plants

Potamogeton crispus

Found in an alkaline ditch at River Canard (TRT) and in an alkaline pool beside the Ojibway Salt Mine (TRT). Salinity at the latter location was 7 g/L in early spring. Concentrations of Na in the water ranged from 2250 to 3000 μg/g at both sites. This pondweed is widespread in southern Ontario, usually being found in Ca-rich water.

Potamogeton foliosus

Widespread in Ontario, this pondweed was found in pools in a brine field west of the Windsor Salt Factory (TRT), in pools beside the Ojibway Salt Mine (TRT), and in a pool near a running well at Amherstburg (TRT). Sodium concentrations in the water at these sites ranged from 2000 to 3000 μg/g.

Potamogeton pectinatus

Sago Pondweed was the only aquatic in a large isolated pool in the brine field at River Canard (TRT). The salinity of the pool in early spring was 10 g/L and the pH of the water was 8.0. Levels of Na through the summer varied from 4300 to 5200 μg/g. This species is widespread in alkaline Ca-rich waters.

Zannichellia palustris

Found in an alkaline pool (Na 2250 to 3000 μg/g) near the Windsor Salt Mine (TRT). Widespread but uncommon in Ontario, Horned Pondweed occurs in brackish water along the Atlantic coast.

Najas minor

Occurred in 10–30 cm of water in ditches beside the River Canard brine field (TRT) and in a pool beside a brine field east of the Windsor Salt Factory (TRT). Concentration of Na in the water of these sites varied from 2500 to 2700 μg/g. This introduced naiad was first collected at Rondeau Park: in shallow water at edge of marsh, the Eau, Lake Erie, 7 September 1961, *J. H. Soper, 9283A, R. D. Ussher and M. D. Eddy* (*sub N. gracillima*) and later by A. A. Reznicek (personal communication) at Point Pelee in 1976. These and the collections from River Canard and Windsor are the only Ontario locations and it had not been previously reported for the province (Boivin 1966–67; Scoggan 1978–79). A European species, it apparently invaded North America about 1930 (Merilainen 1968; Wentz and Stuckey 1971).

Muhlenbergia asperifolia

Catling et al. (1977) reported this western grass from Na-rich sites at the Windsor Salt Factory and near Niagara Falls. Levels of Na at the Windsor site ranged from 800 to 2050 μg/g.

Crypsis (Heleochloa) schoenoides

This European grass was reported from a Na-rich site at the Windsor Salt Factory (Catling et al. 1977), and recently discovered with *Suaeda calceoliformis* along the median of Ontario Highway 401 near London, Middlesex County, 25 August 1979, *P. M. Catling* (TRT).

Spartina patens

Catling et al. (1977) reported Salt-meadow Cordgrass from Na-rich sites near the Windsor Salt Factory. Levels of Na ranged from 3300 to 5300 μg/g.

Diplachne acuminata
Salt-meadow Grass was reported from a Na-rich site near Niagara Falls (Catling et al. 1977), where it was associated with *Aster brachyactis, Panicum dichotomiflorum* var. *geniculatum,* and *Muhlenbergia asperifolia.* This western grass may be spreading along roadsides in northeastern North America as a result of the use of de-icing salt. It was recently found at several alkaline sites along Interstate Highway 90 in Cayuga County, New York State, associated with other halophytes (TRT). McNeill (1979) has recently established the correct name of this taxon, previously called *Leptochloa fascicularis* var. *acuminata.*

Poa arida
This grass of alkaline sloughs in the western interior of North America was found in the alkaline median of Ontario Highway 401 at Towerline Road, near Woodstock, East Oxford Township, 16 September 1979, *P. M. Catling and V. Brownell* (DAO). This collection has all the features of *P. arida* except that the lower glumes are often three-nerved. Scoggan (1978–79) noted that *P. glaucifolia* may be merely the larger flowered extreme of *P. arida.*

Puccinellia distans
Alkali Grass is widespread throughout much of southern Ontario, found in waste places and along roadsides. It has been found in all alkaline habitats studied, often being dominant in the most highly alkaline places. Levels of Na have varied from 500 to 6375 $\mu g/g$ and soil pH from 7.7 to 8.6. The plant grows equally well in calcareous soils with low Na concentrations, and has been found on several occasions in Toronto, growing along the chalk lines marking playing fields.

Agropyron repens
Quack Grass was found in most of the alkaline areas surveyed, in soil with Na levels from 70 to 3200 $\mu g/g$. This species is common throughout much of southern Ontario.

Hordeum jubatum
Foxtail Barley is found in ruderal habitats, especially roadsides throughout southern Ontario. Although soil Na levels from 500 to 1500 $\mu g/g$ and soil pH to 8.2, have been recorded from habitats about Toronto and at the Windsor Salt Factory, it can apparently grow in areas of lower Na levels.

Carex praegracilis
The recent spread of this western sedge into southern Ontario along roadsides has been described by Reznicek et al. (1976). Levels of Na from 200 to 1500 $\mu g/g$ have been recorded. Additional locations to those mapped by Reznicek et al. (1976) include the alkaline median of the Queen Elizabeth Way at St. Catharines, Regional Municipality of Niagara (TRT); open alkaline median of Ontario Highway 401, 5 mi [8.1 km] W of Currie Hill Road (interchange 128), 7.3 mi [11.7 km] W of Quebec-Ontario border, Glengarry County (CAN, DAO, TRT); open alkaline soil of median of Ontario Highway 401, 1.7 mi [2.7 km] W of Moulinette Road to Long Sault, Stormont County (CAN, DAO, TRT); median of Ontario Highway 401, ½ mi [0.8 km] W of interchange 115 at Prescott, Augusta Township, Grenville County (CAN, TRT); in wet depression of Ontario Highway 401 median, 2 mi [3.2 km] W of Palace Road interchange near Napanee, Lennox and Addington County (CAN, DAO, TRT).

Eleocharis erythropoda
This spike-rush was found in permanently moist, moderately alkaline soil near a salt storage depot and snow dump at Toronto, York County (TRT), near the Windsor Salt Factory (TRT), and also along the alkaline median of Ontario Highway 401 in Glengarry County (CAN, DAO, TRT). Levels of Na at these locations did not exceed 2170 $\mu g/g$. This species is widely distributed in southern Ontario. The recent collections from alkaline sites have achenes < 1 mm broad, scales < 3.4 mm, and culms not especially thickened or inflated, and therefore do not represent *E. halophila* despite the fact that the scales are acute or sub-obtuse at the apex. The scales of *E. erythropoda* from various calcareous marshes in Ontario appear not to differ significantly in apical shape from those of plants growing in coastal salt marshes, usually referred to *E. halophila.* Furthermore plants from brackish coastal marshes do not always have markedly thickened or inflated culms as compared with inland *E. erythropoda.*

Juncus balticus
This rush occurs on the upper levels of salt marshes along the Atlantic and James Bay coasts. In southern Ontario it is essentially confined to littoral meadows along the shores of the Great Lakes. It has only recently spread inland (probably from the lakeshores) along roadside ditches where soil pH values of 8.2 and Na levels to 1425 $\mu g/g$ have been recorded.

Juncus compressus
Perhaps introduced to North America from Eurasia (Scoggan 1978–79), this rush was apparently first collected in Ontario along the Mississippi River in Carleton County on 4 July 1931, *N. C. Fassett 13280* (CAN) where it was later collected by W. G. Dore and W. J. Cody in 1959 (DAO, TRT). We have recently discovered this species in roadside ditches at several localities about Toronto; at Burlington, Halton County; at Ottawa; and at Whitby, Ontario County (TRT). It has also been recently discovered in roadside ditches near Bradford and several other localities in Simcoe County (DAO, TRT). In addition to these Ontario localities we recently found *J. compressus* along the open alkaline sides of Quebec Highway 20 near Pointe-Claire, Montreal County, Quebec (TRT). There is no doubt that this plant is spreading rapidly along roadsides in southern Ontario. It appears to be able to flourish in relatively dry and well-drained sites as well as in wet or moist ditches. All locations where this species was found had a relatively high pH (7.5 to 8.2) and Na levels up to 2700 $\mu g/g$.

Juncus gerardii
Black Grass (actually a rush) has been recorded from 10 localities in southern Ontario, of which four were discovered during our survey of alkaline habitats: Montrose Roundhouse, Michigan Central Railway Yard, Montrose, Regional Municipality of Niagara, 25 August 1904, 6 September 1909, *W. Scott* (CAN, DAO, TRT); Niagara Roundhouse, Niagara Falls, Regional Municipality of Niagara, 12 September 1903, *W. Scott* (DAO, TRT); Ashbridges Bay, Toronto, 27 August 1904, *W. Scott* (TRT); Essex, Essex County, 29 July 1913, *M. O. Malte* (CAN); abandoned railway cut, concession 1, lot 25, Hope Township, Durham County, 12 July 1948, *H. Reeve 87* (DAO); in wet depression receiving runoff from rock-salt storage depot, Na to 2450 $\mu g/g$, Don

Valley north of Bloor Street bridge, Toronto, York County, 43°41′N, 79°22′W, 20 October 1974, *P. M. Catling & S. M. McKay* (TRT); several large clumps in open alkaline soil with Na levels to 1060 $\mu g/g$, foot of Leslie Street, Toronto, York County, 43°39′N, 79°19′W, 10 November 1974, July 1975, 20 September 1975, *P. M. Catling & S. M. McKay* (TRT); several large colonies and one continuous area about 760 m^2 dominated by this species, moist alkaline soil with Na to 14000 $\mu g/g$, slopes along the south side of the Maitland River, below the Sifto Salt brine well operation at Goderich, 16 August 1975, *P. M. Catling & S. M. McKay* (TRT); moist alkaline soil with Na levels to 4700 $\mu g/g$, Windsor Salt Factory, 17 May 1975, 21 September 1975, *P. M. Catling & S. M. McKay* (TRT). Black Grass is characteristic in salt marshes along the Atlantic coast at levels where it is periodically inundated with sea water. In Ontario it occupies sites which are more alkaline than those occupied by *J. compressus* and is not spreading along roadsides to the same extent. It is undoubtedly an introduction in southern Ontario, probably from the Atlantic coast.

Polygonum aviculare
Prostrate Knotweed is quite common in southern Ontario along roadsides, in wastelands, lawns, and gardens. It is frequently present in alkaline soils. Soil Na levels varied from about 650 $\mu g/g$ at some Toronto sites to 2050 $\mu g/g$ on wasteland near the Warwick Salt Works, Lambton County.

Polygonum erectum
This knotweed occurs with various other halophytes in highly alkaline soils (pH 8.3) (e.g., near salt stockpiles on the Toronto waterfront, TRT). Because of its superficial resemblance to some forms of *P. aviculare* it is probably often overlooked.

Chenopodium murale
Nettle-leaved Goosefoot was found in association with other distinctly halophytic species along Ontario Highway 401 near Woodstock, Oxford County (DAO, TRT). A native of Eurasia, it is widespread in Canada.

Chenopodium glaucum var. *salinum*
Both the typical Eurasian var. *glaucum* of the Oak-leaved Goosefoot, and the mostly western North American var. *salinum*, occur in our area but only var. *salinum*, with more sharply serrate leaves and bracts subtending the inflorescence, was present in the alkaline areas that we surveyed. Soil Na levels ranged from 280 $\mu g/g$ at Toronto to 13500 $\mu g/g$ below the Goderich brine wells.

Atriplex patula var. *hastata*
Halbred-leaved Atriplex was recorded in all alkaline sites studied. Levels of Na varied from 2550 to 17700 $\mu g/g$. The plant is clearly tolerant of soil with high Na levels. It occurs in alkaline habitats in western North America and on the salt marshes of the Atlantic coast. Plants referrable to var. *littoralis* have been found at the following locations: waste place, Toronto, York County, 10 September 1955, *L. T. Owens* (TRT); alkaline soil at snow dump north of Bloor Street bridge, Don Valley, Toronto, 19 October 1974, *P. M. Catling & S. M. McKay* (TRT); alkaline roadside near Grimsby, Regional Municipality of Niagara, 43°12′N, 79°34′W, 14 September 1975, *P. M. Catling & K. L. McIntosh* (TRT).

Kochia scoparia
Introduced from Europe, Summer-cypress is found locally throughout southern Ontario, usually in alkaline sites along roads, along railways, and on landfill and in waste places about cities and towns. It has been known in Ontario since 1880 when it was collected at Ottawa by Fletcher (Rousseau 1968). This is the only plant we have found growing in very dry soils with very high Na levels, ranging from 287 $\mu g/g$ at Toronto to 10200 $\mu g/g$ at the Ojibway Salt Mine, and to 18500 $\mu g/g$ at Goderich.

Suaeda calceoliformis
Growing in the median of Ontario highway 401, 1 km W of Highway 100 to London, Westminster Township, Middlesex County, 25 August 1979, *P. M. Catling* (CAN, DAO, TRT). Sea-blite formed dense stands in ephemeral pools of the median often associated with other halophytes such as *Spergularia media* and *Puccinellia distans*. Bassett and Crompton (1978) did not show a southern Ontario locality so that this is apparently the first. McNeill et al. (1977) have shown that *S. calceoliformis* is the correct name for plants previously called *S. depressa*.

Spergularia marina
Previously known in southern Ontario only from alkaline ground at a snow dump and near a salt storage depot at Toronto (Catling and McKay 1975; CAN, DAO, TRT), and from Windsor (W. Botham 1975, unpublished list for Essex County, 23 pp.), this sand-spurrey has recently been found at two additional locations in Toronto, both of which were relatively low and flat places along roadsides where de-icing salt run-off accumulated and upward percolation and surface evaporation of water concentrated the Na to levels of 4500 $\mu g/g$ (CAN, DAO, TRT). In 1975 a few hundred plants were located by us in the immediate vicinity of the Windsor Salt Factory, and to the east around the brine field on Matchette Avenue. Here Na levels varied from 500 to 6375 $\mu g/g$ (CAN, DAO, OAC, TRT). Later, another station was discovered in an open alkaline site with *Puccinellia distans*, *Atriplex patula* var. *hastata*, and *Aster subulatus* in the immediate vicinity of a running well about 1 mi [1.6 km] NE of Amherstburg, Essex County (TRT). On 24 May 1976, a *Spergularia* sp. was collected along the median of the Queensway between Pinecrest Road and Woodroffe Avenue in Ottawa (Figure 1), Regional Municipality of Ottawa-Carleton (about 45°23′N, 75°46′W). It was transplanted to the greenhouse where it flowered and set seed by 8 July, and was clearly *S. marina* (DAO, TRT). Although widespread inland in western North America, Rossbach (1940, p. 81) indicated only one inland station for this species in eastern North America (at the south end of Lake Michigan). It is frequent in salt marshes along the Atlantic coast where it grows from the upper to the lower tidal levels and may be subject to frequent inundation with brackish water. Collections from the Windsor (and Detroit, A. A. Reznicek, personal communication) area differ from the Toronto specimens in having glandular-papillose seeds that are not winged, and in being glandular-pubescent at least on the pedicels and sepals. The plants from several locations in Toronto (at least 400 plants) are essentially glabrous, and the seeds are not glandular-papillose and usually not at all winged. In one out of seven capsules, however, two to eight

FIGURE 1. A typical halophyte habitat resulting from the use of de-icing salt. *Spergularia marina, Atriplex patula* var. *hastata, Puccinellia distans,* and *Agropyron repens* dominate this portion of the Queensway between Pinecrest Road and Woodroffe Avenue in Ottawa, Regional Municipality of Ottawa-Carleton.

seeds with obvious wings 0.3–0.4 mm wide were found. The Ottawa collections are similar to those from Toronto. Some plants of both *S. marina* and *S. media* in southern Ontario are perennial; this has been supported by observation of plants in the field which survived the winter of 1975–76.

Spergularia media

Growing in open alkaline soil with Na 2200 to 5500 $\mu g/g$ and pH 7.5 to 8.2, about temporary pools in the median of the Queen Elizabeth Way at several points between Jordan and Grimsby, Regional Municipality of Niagara, 43° 12′N, 79° 34′W, 14 September 1975, *P. M. Catling & K. L. McIntosh* (CAN, DAO, OAC, TRT); median of Queen Elizabeth Way at Winona, Saltfleet Township, Wentworth County, 10 September 1976, *P. M. Catling & K. L. McIntosh* (CAN, DAO, TRT); open ditch receiving salty run-off from highway at Gulf Center on Ontario Highway 401, 4.3 mi [6.9 km] E of exit 16 (Highway 76) to West Lorne, Aldborough Township, Elgin County, 15 August 1977, *P. M. Catling* (DAO, TRT, UWO); open saline median of Ontario Highway 401 near Highway 59, 2 mi [3.2 km] S of Woodstock, East Oxford Township, Oxford County, 17 September 1977, *P. M. Catling* (DAO, TRT); in alkaline median of Ontario Highway 401, 2 mi [3.2 km] E of Ontario Highway 100 to London, Westminster Township, Middlesex County, 13 July 1979, *P. M. Catling* (TRT). This sand-spurrey was previously known in the east only from central and coastal New York State (Rossbach 1940), where it is considered to have been introduced (Fernald and Wiegand 1910). It is recently adventive along a highway in Illinois (Mohlenbrock and Evans 1974), and was noticed by us at several points along Interstate Highway 90 in New York State (TRT), along Interstate Highway 90 in Berkshire County, Massachusetts (CAN, NEBC, TRT), and along Quebec Highway 20 near Pointe-Claire, Montreal County, Quebec (CAN, DAO, TRT). It seems to be spreading rapidly along highways in response to the use of de-icing salt. The eastern plants referrable to *S. media* apparently differ from those in the west in having the petals rose-purple instead of white, equal or nearly equal in length to the sepals instead of shorter, and glandular-pubescent instead of glabrous (Rossbach 1940, p. 117).

Ranunculus cymbalaria

In southern Ontario, Seaside Crowfoot is known from only three localities: Wingham, Huron County; Goderich, Huron County (CAN, TRT); Carlsbad Springs, Regional Municipality of Ottawa-Carleton (DAO). Where this attractive little

buttercup grew around shallow pools below the brine wells at Goderich (CAN, TRT), Na levels ranged from 2000 to 4700 µg/g. In northern Ontario, it is apparently rather rare and local inland, but frequent, especially in tidal estuaries, along the shores of James Bay and Hudson Bay. It is frequent also in the salt marshes along the north Atlantic coast and in alkaline mudflats in Manitoba.

Myriophyllum spicatum
Found in ditches adjacent to the brine field at River Canard (TRT), and in alkaline pools at the Ojibway Salt Mine (TRT). Levels of Na in the water varied from 2250 to 3000 µg/g. Eurasian Watermilfoil is recently adventive in southern Ontario (Aiken et al. 1979), and also in Michigan (Coffey and McNabb 1974).

Eleagnus angustifolia
A native of Europe, Russian Olive is cultivated in parks, graveyards, and occasionally in gardens, at Toronto, London and probably elsewhere. There is one specimen at TRT labelled "escaped from cultivation, Toronto, 4 July 1936, *D. L. Robb*." It has also escaped from cultivation onto highly alkaline wasteland near the Windsor Salt Factory (TRT) and represents the only woody vegetation established in the area.

Centaurium pulchellum
Titcombe, Windsor, Essex County, 43° 18'N, 83°01'W, 8 October 1967, *W. Botham 550* (CAN); open alkaline ground east of Windsor Salt Factory, Na to 2200 µg/g, 8 August 1975, *P. M. Catling & S. M. McKay* (CAN, TRT). We have noticed this introduced species at several other places along roadsides in the vicinity of Windsor. In addition, it occurs near a running well at Amherstburg, 2 September 1976, 15 August 1977, *P. M. Catling & S. M. McKay* (TRT). These are the only records for the province. Native to Europe, Small Centaury was first reported for Ontario from Windsor, Essex County (W. Botham 1975, unpublished list for Essex County, 23 pp.). Recent Ontario collections have been determined by C. R. Broome of the University of Maryland.

Solidago sempervirens
Seaside Goldenrod was discovered near Windsor by W. Botham in 1974 (W. Botham 1975, unpublished list for Essex County, 23 pp.). During our 1975 survey of alkaline habitats near Windsor, we found it to be common (a few hundred plants at least) at both the Windsor Salt Factory, and in the brine fields east of Ontario Highway 18 south of the Canard River (CAN, DAO, TRT). A few plants were observed also at the Windsor Salt Mine, Ojibway. Sodium levels ranged from 2200 to 4550 µg/g. This is an eastern coastal species characteristic of salt marshes. The stations near Windsor in Ontario and around Chicago in Illinois (Swink 1974) are apparently the only inland stations in the northeast.

Aster brachyactis
This aster is known from a variety of alkaline sites in southern Ontario, including roadsides, landfill sites, and railway yards. The earliest collections (1897, 1898) are from the roundhouses (in railway yards) at Montrose (CAN) and Niagara Falls (CAN, TRT) both Regional Municipality of Niagara. It is known from several localities about Toronto where it was apparently first collected in 1942 (CAN, DAO, TRT). Other more recent localities include Highland Creek, York County (TRT); Ottawa and Ramsayville, Regional Municipality of Ottawa-Carleton (DAO); Cornwall, Stormont County (DAO); and Summerstown, Glengarry County (DAO). A recent collection from alkaline ground near the Windsor Salt Factory, 21 September 1975, *P. M. Catling & S. M. McKay* (TRT), may represent the first collections from extreme southwestern Ontario. Near a salt storage depot and snow dump at the foot of Leslie Street, Toronto, Na levels ranged from 337 to 2170 µg/g. Our plants (Ontario and southwestern Quebec) have been referred to *A. laurentianus* (Boivin 1966–67; Rousseau 1968; Scoggan 1978–79). Having closely examined isotypes and topotypes (CAN, DAO), we find that the plants described by Fernald (1914) as *A. laurentianus* are endemic to the southern Gulf of St. Lawrence. These differ consistently from the widespread western plants in being more succulent and glabrous, with the leaves and bracts wider and somewhat shorter, and essentially smooth-margined rather than serrulate-bristled. The western plants, native from British Columbia to Manitoba, are referrable to *Aster brachyactis*, which has its type locality in western North America. *Aster brachyactis* from southern Ontario and southwestern Quebec, where the species is certainly adventive, is similar in all respects to the plants referrable to *A. brachyactis* from the mid-west. In northern Ontario, *A. brachyactis* is adventive at Thunder Bay city, but probably native in alkaline mudflats about James Bay.

Aster subulatus
This coastal salt-marsh aster was previously known inland in Onondaga County, New York State (var. *euroauster*, see Fernald 1950), and in alkaline places near Detroit, Michigan (Farwell 1916; Brown 1917; Fernald 1950) and at River Canard in Essex County (W. Botham 1975, unpublished list for Essex County, 23 pp.). It has been found at several alkaline sites in Essex County: prairie 2 mi [3.2 km] S of Windsor, September 1954, *C. M. Rogers* (DAO, photo of specimen at WUD); near the mouth of the Canard River, Anderdon Township, Essex County, 42° 10'N, 83°06'W, 28 September 1969, *W. Botham 1005* (CAN); open alkaline soil, Windsor Salt Factory, 21 September 1975, *P. M. Catling and S. M. McKay* (TRT); open alkaline soil in brine field south of River Canard, Na 10060 µg/g, 21 September 1975, *P. M. Catling and S. M. McKay* (TRT); alkaline soil about a running well northeast of Amherstburg, 2 September 1976, 15 August 1977, *P. M. Catling and S. M. McKay* (CAN, DAO, TRT).

Pluchea purpurescens var. *succulenta*
Salt-marsh Fleabane was apparently first discovered in Ontario by Wilfred Botham (W. Botham 1975, unpublished list for Essex County, 23 pp.): River Canard and Ontario Highway 18, Essex County, 42° 10'N, 83°06'W, 24 August 1975, *W. Botham* (CAN); open alkaline soil around brine pool south of bridge over River Canard, Na 2700 to 17700 µg/g, 21 September 1975, *P. M. Catling & S. M. McKay* (TRT); moist ditches near Windsor Salt Factory, September 1977, *P. M. Catling and K. L. McIntosh* (TRT). These are the only Ontario records, but this plant of Atlantic coastal salt marshes is also reported from western New York State (Fernald 1950), and the var. *purpurescens* is reported from alkaline habitats at Detroit, Michigan (Farwell 1916; Fernald 1950).

Other Possibly Halophytic Species

Other species were noted in apparently less alkaline, but still Na-rich substrates (500 to 1000 $\mu g/g$). None of these species (Table 1) is confined to the alkaline sites studied; however, they appear to be tolerant, at least to some degree, of abnormally high Na levels, and frequently grow with halophytic species, perhaps in substrates where Na levels had previously been much higher.

Some plants grow on the gravelly shoulders of highways that receive a heavy salt spray and salty run-off. Drainage is good, however, and high salt levels are not maintained. These species are annuals and they presumably avoid the salt by late germination. Apparently included here are *Panicum capillare, Digitaria sanguinalis, Setaria viridis, Sporobolus neglectus, Sporobolus vaginiflorus, Polygonum achoreum, Chenopodium album, Medicago lupulina, Euphorbia supina, Artemisia biennis,* and *Ambrosia artemisiifolia*. An unusually succulent form of the annual *Anagallis arvensis* is also occasionally seen along the gravelly edges of highways, sometimes associating with *Spergularia marina* (TRT).

The reference to Alkali Cordgrass (*Spartina gracilis*) in southwestern Ontario (Boivin 1966–67, p. 497) is apparently based on a specimen at DAO: bottomland of Maitland River, about 1 mi [1.6 km] above its entrance to Lake Huron, Goderich, Huron County,

TABLE 1—Species which were found in alkaline substrates (pH 8.0 to 8.3, Na to 1000 $\mu g/g$) in southern Ontario. These species are not confined to the alkaline sites studied. * = used in highway seed mix

Species	Aquatic	Moist	Periodically moist	dry
Typha angustifolia		x	x	
Potamogeton richardsonii	x			
Triglochin maritimum		x	x	
Vallisneria americana	x			
Panicum dichotomiflorum var. *geniculatum*			x	x
Echinochloa muricata			x	x
Hierochloe odorata			x	x
Sporobolus asper			x	x
Agrostis stolonifera var. *compacta*			x	x
Phragmites australis			x	x
**Festuca arundinacea*				x
**Festuca rubra*				x
Cyperus esculentus			x	x
Cyperus odoratus			x	x
Scirpus americanus		x	x	
Eleocharis acicularis		x		
Heteranthera dubia	x			
Rumex crispus		x	x	
Rumex maritimus		x		
Rumex mexicanus			x	x
Atriplex hortensis				x
Atriplex patula			x	x
Potentilla anserina		x	x	
Medicago lupulina				x
Melilotus alba				x
Epilobium hirsutum			x	x
Daucus carota				x
Lycopus asper		x	x	
Dipsacus sylvestris				x
Ambrosia artemisiifolia				x
Matricaria maritima var. *agrestis*				x
Bidens cernua			x	
Bidens frondosa			x	
Sonchus arvensis			x	x
Sonchus oleraceus			x	x
Sonchus uliginosus			x	x
Lactuca scariola				x

26 July 1948, *W. G. Dore 8891*. Although the spike and spikelets of this specimen are relatively short (spikelets 7.5–9.0 mm), the size of the plant, short scabrous hairs on the keel of the glume, short awns, and stout rhizome with tough brownish scales indicate *S. pectinata*. Although this latter species is widespread in Ontario in calcareous prairie and along lakeshores, we have not yet found it here in Na-rich soils.

A number of plants grow in saline, but not necessarily alkaline or Na-rich, soils in Ontario, but in other parts of their range do grow in salt marshes and/or alkaline sloughs. Included are *Potamogeton perfoliatus, Triglochin palustris, Sagittaria rigida, Agrostis stolonifera* var. *palustris, Spartina pectinata, Chenopodium rubrum, Myosurus minimus, Elatine minima, Samolus parviflorus, Phyla (Lippia) lanceolata,* and *Erechtites hieracifolia*. Presumably these species have developed salt-tolerant ecotypes in parts of their ranges, but these have not yet made their way into the highly alkaline habitats in Ontario. The local plants are either not salt tolerant or insufficiently aggressive to colonize the highly alkaline habitats.

Infraspecific Halophytes

Certain plant species that are widespread in Ontario have more or less distinct halophytic varieties in parts of the overall distribution where Na-rich environments occur. *Juncus bufonius* was found in slightly alkaline sites at Toronto where soil Na levels reached 500 μg/g and elsewhere along slightly alkaline roadside ditches. None of these plants was referrable to the halophytic var. *halophilus* judging by the relatively long, narrow and gradually tapered petals. The latter variety is found in the James Bay and Atlantic coastal marshes, and in alkaline sloughs to the west of Ontario. *Salsola kali* var. *tenuifolia* provides another example. In southern Ontario it is a common weed of dry disturbed sites. The more succulent and halophytic *S. kali* var. *kali*, found along the edges of Atlantic coastal marshes and on sea beaches, has not yet been found in southern Ontario.

Other species have salt-tolerant ecotypes which are not recognized taxonomically. For example, salt-tolerant ecotypes of *Festuca rubra* exist in the salt marshes of the lower St. Lawrence and along the Atlantic coast where the plants grow in soil with very high Na levels but a salt-tolerant ecotype has not yet become well established in southern Ontario. Possibly the ecotype used in seeding Ontario highway verges (H. Spence 1971, Ontario Department of Highways unpublished report, "Establishment and maintenance of ground cover on highway rights of way, 10 pp.) is not as salt tolerant as the coastal races, or it may be inferior in competition with *Puccinellia distans*.

Origin of Southern Ontario Halophytes

With the exceptions of *Potamogeton crispus, P. foliosus, P. pectinatus, Zannichellia palustris, Eleocharis erythropoda, Ranunculus cymbalaria,* and perhaps *Polygonum aviculare*, all plants definitely associated with relatively high levels of Na salt (2000 μg/g Na) are recently introduced. The exceptions listed above are all capable of growth in non Na-rich habitats and in fact are widespread in Ontario and are likely native. It is possible, however, that the plants of these species found in Na-rich habitats represent introduced Na salt-tolerant strains.

We can be fairly certain of the recent introduction of the other well documented halophytes since the reports and collections for Ontario (and in most cases for the inland northeast generally) are comparatively recent, and are from habitats resulting from human disturbance. In addition, a survey of historical and geological records suggests that salt-rich (NaCl) habitats were not present in southern Ontario at the time of settlement. Halophytic plants appear to have moved into southern Ontario recently from alkaline habitats to the west (e.g., *Muhlenbergia asperifolia, Diplachne acuminata, Poa arida, Spergularia media, Aster brachyactis*), from the eastern coastal salt marshes (e.g., *Spartina patens, Juncus gerardii, Solidago sempervirens, Aster subulatus, Pluchea purpurescens* var. *succulenta*), or from Europe (*Najas minor, Crypsis (Heleochloa) schoenoides, Juncus compressus, Puccinellia distans, Kochia scoparia, Myriophyllum spicatum, Centaurium pulchellum*). *Spergularia marina* and *Suaeda calceoliformis* could have spread into Ontario from the east or west, or both. The origin of *Polygonum aviculare* and *Atriplex patula* also remains a mystery. These latter species may have come from anywhere in the northern hemisphere and/or they may have been present locally in Ca-rich habitats.

Habitats for halophytes were provided by the salt industry which was well developed in southwestern Ontario by the late 1800s and early 1900s (Hewitt 1962). The use of salt to melt ice in railway yards and salt stockpiling in railway yards also provided habitat. The increasingly extensive use of de-icing salt along roads over the past 25 yr and the consequent concentration of NaCl and decline of non-adapted vegetation (Foster and Maun 1978) has allowed a rapid colonization by halophytes. The habitats, the avenues (i.e., the roads and highways) and the means (i.e., the highway traffic) of dispersal were all available simultaneously. Except for *Festuca arundinacea* and *F. rubra*, which are seeded (H. Spence 1971, *op. cit.*), all of the halophytes listed appear to have spread to and established in the sites where we found them without any conscious help from man. Some are probably dispersed

primarily by automobiles (e.g., *Spergularia* spp., *Puccinellia distans*, and *Carex praegracilis*, see Reznicek et al. 1976). Other species may have been introduced by adhesion to waterfowl (e.g., *Solidago sempervirens*, *Pluchea purpurescens* var. *succulenta*, *Aster subulatus*); ducks and wading birds frequent alkaline pools in the Windsor and River Canard areas.

Zonations of Halophytes

In several places in southern Ontario where halophytic plants are found, well developed associations occur forming zonations relative to water content and Na levels. This was well demonstrated in some of the alkaline sites near Windsor (Figure 2). Around the edges of ephemeral or permanent pools containing *Potamogeton foliosus*, was a fringe of *Spergularia marina*, followed by a band of *Puccinellia distans*, followed by *Agropyron repens* and *Atriplex patula* var. *hastata*. The Na levels in the rooting medium decreased from over 2000 μg/g where the *Spergularia marina* grew to a few hundred micrograms per gram where *Agropyron repens* was dominant. Similarly, temporary pools at the brine field at River Canard were surrounded by *Atriplex patula* followed by a zone of *Puccinellia distans* and *Solidago sempervirens*. Beyond this on drier ground was a zone dominated by *Agropyron repens*. Around the brine pond containing *Potamogeton pectinatus* at River Canard was *Atriplex patula* and locally dense stands of *Pluchea purpurescens* and *Aster subulatus*; these graded into a poor growth of *Typha angustifolia* which gradually improved as Na levels in the soil further decreased. Zonations of this general type, although not always so obvious, have been noticed everywhere in southern Ontario where halophytes have been found.

Presence of some halophytes is clearly related to the water content of highly alkaline soils. *Kochia scoparia* grows only in dry alkaline soils and is generally replaced by other species in wetter sites even when the

FIGURE 2. Halophytes forming zonations around ephemeral pools in a brine field on the east side of Sandwich Street, west of Matchette Avenue, south Windsor, Essex County. *Agropyron repens* in the foreground, with light bands of *Puccinellia distans*, *Spergularia marina*, and *Atriplex patula* var. *hastata* forming a fringe around temporary pools where salt has crystallized on the surface.

Na concentration remains the same. Dry highly alkaline habitats are less frequent than wet or periodically wet ones because Na tends to be leached out of well drained sites and concentrated in those that are lower, and poorly drained, by evaporation. *Spergularia marina* appears to prefer periodically wetter (inundated) sites than *S. media* although both may be found in soil that is rock hard after a few weeks of drought. *Pluchea purpurescens* var. *succulenta* appears to require alkaline soil that is continuously moist.

Economic Value of Halophytes

With the ever increasing automobile traffic and highway construction, and without an alternative to the use of sodium salts to maintain safe and efficient driving conditions during the winter, the use of salt and the development of alkaline habitats along roadways is likely to increase. The seeding of salt-tolerant plant species along road verges is probably the least costly way of maintaining roadside vegetation cover. Various salt-tolerant species have been identified for this purpose (Dewey 1962; Cordukes and Maclean 1973; McElgunn and Lawrence 1973; Hughes et al. 1975). Certain halophytes are spreading rapidly of their own accord, however, and roadside populations of some common plants may be acquiring tolerance (Pitelka and Kellogg 1979). Seeds of halophytic species may be spread over great distances by lodging on the underside of automobiles with the mud splashed from road edges, and also by lodging in the tire treads. Parts of rhizomes and seeds may also be transported by the mowing and grading machines used along the highways, and by highway construction equipment. With relatively little artificial stimulation of the existing halophytes, it may be possible to maintain roadside cover effectively and without the high cost of soil conditioning and reseeding with plants which are less able to withstand highly alkaline conditions.

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Wilfred Botham of Cottam, Ontario provided records of certain halophytes found in Essex County and commented on the manuscript. We also appreciate the helpful suggestions of W. J. Cody (Agriculture Canada) and A. A. Reznicek (University of Michigan). R. Sheath (University of Rhode Island) kindly identified the *Enteromorpha* spp.

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White-tailed Deer Wintering Area in a Hemlock–Northern Hardwood Forest

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Gates, J. Edward and Dan M. Harman. 1980. White-tailed Deer wintering area in a hemlock–northern hardwood forest. Canadian Field-Naturalist 94(3): 259–268.

Environmental factors affecting White-tailed Deer (*Odocoileus virginianus*) utilization of a hemlock – northern hardwood wintering area in western Maryland were evaluated for the unusually severe winter of 1976–1977. Deer activity was concentrated within microhabitats having the highest evergreen basal area and canopy cover, greatest total basal area and canopy cover, minimum wind velocity, and lowest snow depth. The number of deer beds appeared to provide the best means of assessing the cover value of a habitat or vegetation type. Coniferous bottomland dominated by Eastern Hemlock (*Tsuga canadensis*) served as the primary source of shelter and food for the wintering deer herd; however, deer readily foraged for mast where snow cover was scant on the southwest-facing slope dominated by Sugar Maple (*Acer saccharum*).

Key Words: Deer wintering area, deer winter habitat, deer yard, environmental factors, hemlock – northern hardwood forest, *Odocoileus virginianus*, White-tailed Deer.

On northern range, severe winter weather and deep snow usually restrict White-tailed Deer (*Odocoileus virginianus*) to the protective cover of evergreen stands. The winter habitat requirements and the environmental factors affecting "yarding" behavior have been described by many authors (Verme 1968; Telfer 1970; Moen 1968a,b, 1976; Ozoga 1968; Verme and Ozoga 1971; Ozoga and Gysel 1972; Huot 1974). Level coniferous bottomland with a dense overstorey is reportedly favored because of lesser snow depths, more infrared radiation flux, little or no wind, narrower thermal ranges, and warmer mean temperatures. But, few such studies have dealt specifically with hemlock – northern hardwood winter concentration areas.

Throughout most of Maryland, White-tailed Deer are seldom confined to protective cover for prolonged periods because of winter weather. The Allegheny Plateau region differs from the rest of the state, however, in that temperatures are decidedly colder, snowfalls heavier, and storms more intense and of longer duration. During the unusually severe winter of 1976–1977, high winds and low temperatures lasting several days repeatedly occurred during January and February. Deep snow also prevailed from December to late February in western Maryland. This offered an opportunity to study White-tailed Deer in a mid-Appalachian location under winter conditions generally associated with more northern parts of their range. The objective was to determine the relationships between environmental factors, habitat type, and deer utilization of different parts of their winter concentration area.

Study Area

This study was conducted in the Allegheny Plateau region of northeastern Garrett County, Maryland. The deer wintering area bordered Blandy Run Creek which flows from the east into the Frostburg Reservoir (Figure 1). The topography is formed of rolling tableland having 10–35% slopes and nearly level alluvial bottomland along Blandy Run. Moderately deep, well-drained, silt-loam soils are found on the uplands; while poorly-drained, very stony soils formed in mixed, variable material are found on the floodplain (Stone and Matthews 1974). Elevations along Blandy Run range from 716 m at the Reservoir to 823 m above sea-level on bordering ridge crests.

The forests of the high tableland in western Maryland are considered to be a southern extension of the Eastern Hemlock (*Tsuga canadensis*) – White Pine (*Pinus strobus*) – northern hardwood forest (Braun 1950; Brown and Brown 1972). Forested uplands on the study area are composed of Sugar Maple (*Acer saccharum*), American Beech (*Fagus grandifolia*), Red Oak (*Quercus rubra*), Cucumber Tree (*Magnolia acuminata*), Black Cherry (*Prunus serotina*), and a scattering of Eastern Hemlock. Bottomland forests include Eastern Hemlock as the dominant species, along with Yellow Birch (*Betula lutea*), Red Maple (*A. rubrum*), and Rosebay Rhododendron (*Rhododendron maximum*).

This region has a humid continental climate with general atmospheric flow from the west to east. Annual precipitation averages more than 114 cm. The coldest most severe weather occurs in January and February, when minimum temperatures average 0°C

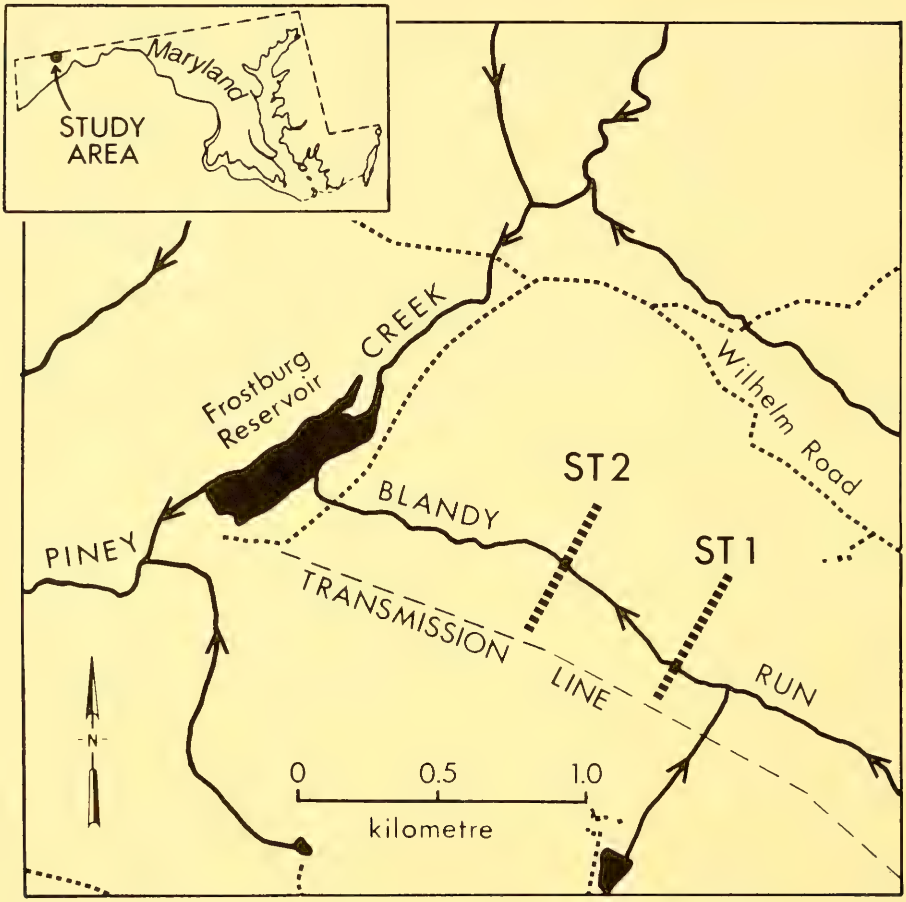

FIGURE 1. Map of the Blandy Run deer wintering area in Garrett County, Maryland, showing location of sampling transects (ST 1, ST 2).

or lower. Annual snowfall averages 180 cm, but has ranged from a high of 320 cm to a low of 99 cm. Prevailing winter winds, clocked at 80.5 to 96.6 km · h^{-1} during storms, are from the west to northwest (climate description from Stone and Matthews 1974).

The severe winter of 1976–1977 was characterized by below-normal temperatures, above-normal snowfall, and prolonged periods of high winds. The mean temperature for January was about 10°C lower than during an average winter. Total snowfall was 238.5 cm, or 58.5 cm greater than normal. January's snowfall alone was 85.6 cm. Periodic blizzard conditions prevailed throughout Garrett County during January and February, and caused deer to concentrate in protective cover. Deer began to disperse from concentration areas with a warming trend in late February.

The Blandy Run deer wintering area has been observed continuously over the last 10 yr by D. M. Harman, who lives near the watershed. Deer have used the area for protective cover at least during this time period. The extent of utilization has varied with the severity of the winter. Based on counts of deer in open fields and on deer sign, the herd size appears to have remained fairly constant.

Materials and Methods

Weekly observations of the deer wintering area began in January and continued through March 1977. Quantitative data on wintering behavior in relation to habitat, weather, and topography were collected in early February after a 13-cm snowfall had obliterated all prior signs of deer activity. At that time, maximum snow depths in the study area measured approximately 55 cm, which was sufficient to impair deer

mobility seriously (Kelsall 1969). Two transects located about 0.5 km apart were established through the deer concentration area perpendicular to Blandy Run (Figure 1). Each transect was 61.0 × 549.0 m and consisted of 18 plots, 61.0 × 30.5 m, with the long axis parallel to the stream. Each plot was then divided into two 30.5 × 30.5 m sample plots. The area covered by both transects totaled 6.7 ha.

Three indices of deer utilization were used to evaluate the environmental factors associated with wintering behavior. Systematic counts of trails (i.e., one deer moving through an area), beds, and pellet groups were made simultaneously in adjoining sample plots within the same elevation interval. The tally of trails, beds, and pellet groups within pairs of adjoining sample plots was used to calculate a mean number per sample plot per day within an elevation interval. Disturbance by humans and/or predators that could have affected deer movement patterns appeared minimal during the sampling period.

Eleven habitat, weather, or topographic variables were measured in each sample plot. Habitat variables included evergreen and deciduous basal area in square metres per hectare and evergreen and deciduous canopy cover percentage. Basal area was determined with a 10-factor angle gauge by averaging two random measurements, one in each sample plot pair. Canopy cover was determined with an ocular tube (Emlen 1967) from 40 random points, 20 in each sample plot pair. Weather variables included wind velocity in kilometres per hour and snow depth in centimetres. Wind velocity was measured with a small hand-held anemometer at a random location in each sample plot. The highest sustained wind observed over a 60-s time interval was recorded. At the time of measurement, winds were constant and from the west-northwest at approximately 35.4 km · h^{-1} in the open. Wind speeds recorded in adjacent plot pairs were then averaged. Although wind velocities were recorded in all 72 sample plots during only one period of sustained high winds, measurements taken in the area on other days supported our results. Snow depth was measured with a ruler at five random points in each sample plot. Ten measurements from adjacent plot pairs were used to calculate the mean snow depth for that elevation interval. Elevation in metres above sea-level was determined to the nearest 0.6 m at the up-slope and down-slope positions of each sample plot pair with a surveying altimeter corrected for barometric pressure. These measurements were averaged to determine a mean sample-plot-pair elevation.

The deer wintering area was divided into three distinct habitat types based on differences in plant species composition and structure. These habitat types were Eastern Hemlock – Sugar Maple on the northeast-facing slope, Eastern Hemlock – Yellow Birch on the bottomland, and Sugar Maple on the southwest-facing slope of the Blandy Run deer concentration area.

A stratified random-sampling design using nested plots was employed to sample the habitat types in late summer 1977. A 90-m^2 sample plot was used to sample plant species >1.5 cm diameter at breast height (dbh). A 22.5-m^2 sample plot was used to sample plant species ⩾50 cm in height but ⩽1.5 cm dbh. This stratum is the one usually available to deer for winter browse. A 3-m^2 sample plot was used to sample those plant species <50 cm in height, which are usually beneath the snow and unavailable to deer, except by cratering. Nomenclature of plant species was based on Gleason (1952).

Results

Sign, Environmental Factors, and Elevation

Because increasing distance from Blandy Run was directly associated with increasing elevation, variables were related to elevation for ease in interpretation; however, the influence of elevation on habitat utilization by deer was probably indirect.

Patterns of habitat utilization based on trail, bed, and pellet-group counts gave similar results, although there were several minor but interesting differences (Figure 2). For example, the number of trails generally increased with decreasing elevation. Deer activity was highest near Blandy Run. Trail counts were also especially high on the southwest-facing slope, and trails extended farther up that slope than the northeast-facing slope. Deer seemed to avoid the upper part of the northeast-facing slope. Beds increased with a decrease in elevation and were found most often on bottomland of Blandy Run, but never close to the stream. Pellet-group counts usually increased with a decrease in elevation, but high counts were recorded from the upper portion of the southwest-facing slope. As with beds, low numbers of pellet groups were recorded near Blandy Run.

The habitat variables showed definite trends with decreasing elevation (Figure 3). Evergreen and total basal area generally increased with decreasing elevation, but then decreased at the stream. But evergreen and total canopy cover continued high at the stream, probably because the forest canopy somewhat overtopped the stream. Deciduous basal area and canopy cover decreased with decreasing elevation.

Microclimate conditions also changed with decreasing elevation (Figure 4). Wind velocity generally decreased with decreasing elevation but increased near the stream. Snow depths also generally decreased with a decrease in elevation. Snow cover was deepest on the northeast-facing slope and shallower on the

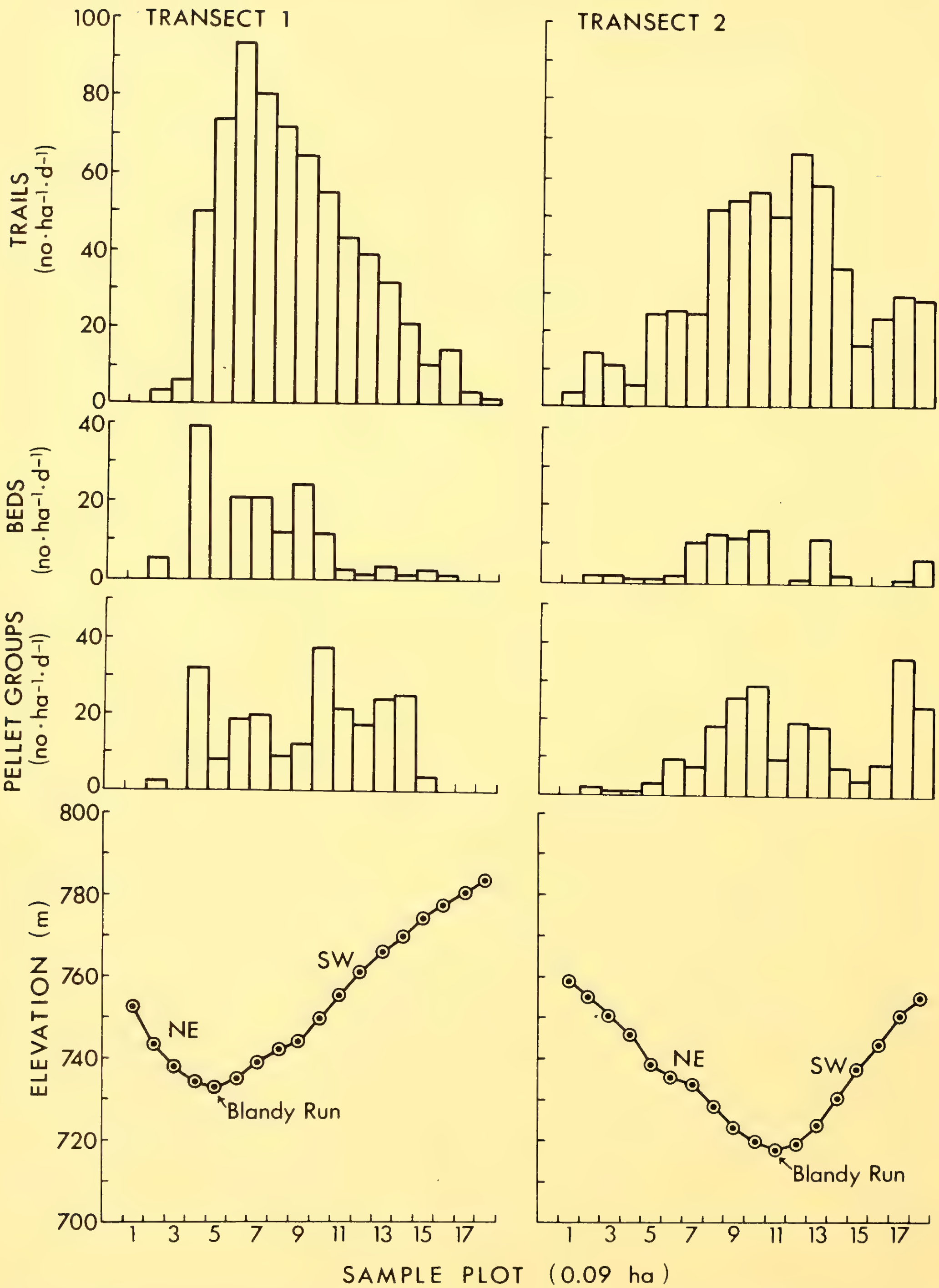

FIGURE 2. The relationship of trail, bed, and pellet-group counts to the elevational gradient across the Blandy Run deer wintering area.

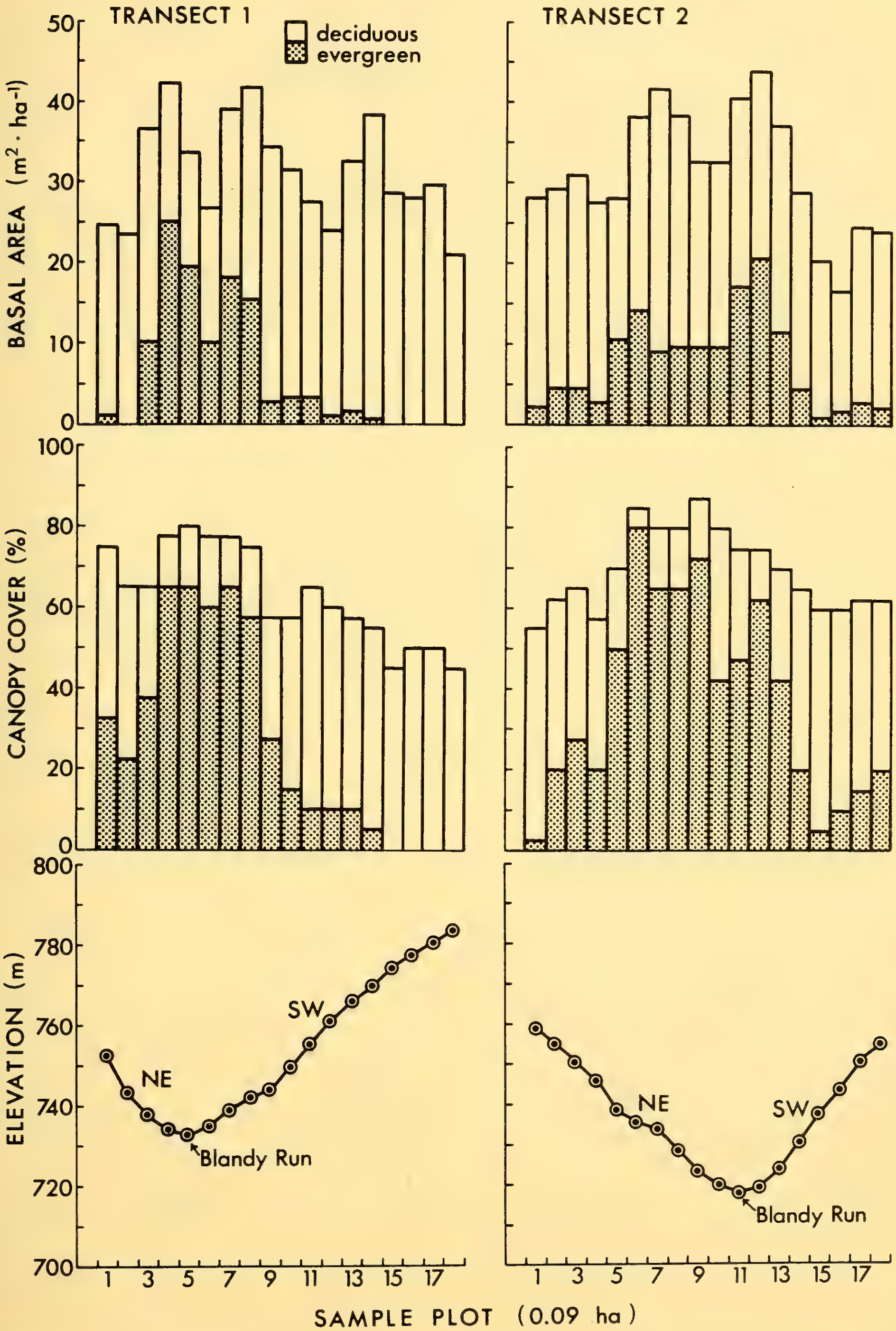

FIGURE 3. The relationship of basal area and canopy cover to the elevational gradient across the Blandy Run deer wintering area.

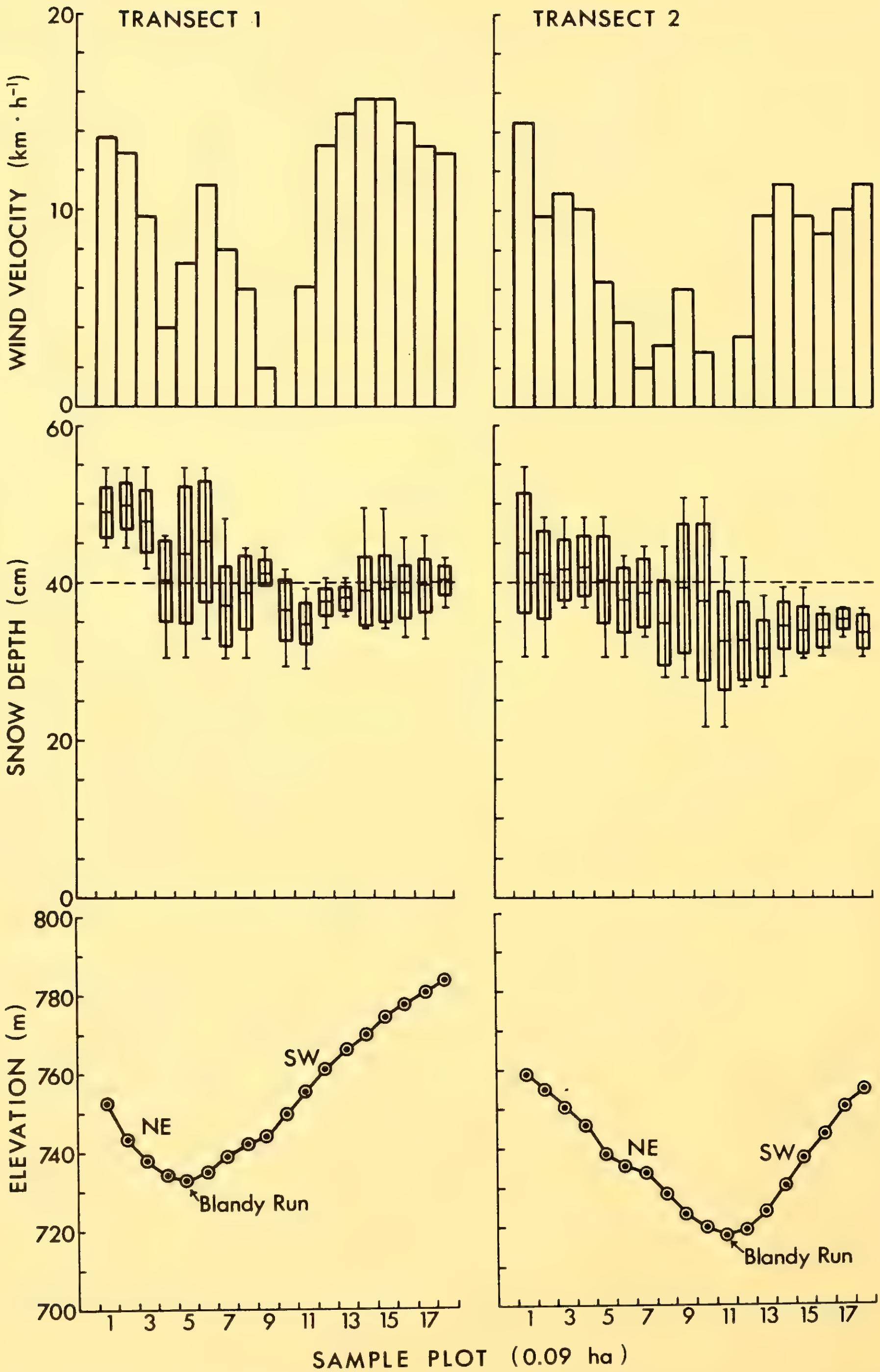

FIGURE 4. The relationship of wind velocity and snow depth (mean ± SD, range) to the elevational gradient across the Blandy Run deer wintering area. The critical snow depth seriously impairing deer mobility is indicated by a dashed line.

southwest-facing slope. Snow depths were more variable at the base of the northeast-facing slope near the stream than elsewhere.

Because the variables measured at transects 1 and 2 showed similar trends with changes in elevation, data were combined and further analyzed using Kendall rank correlation (Siegel 1956, pp. 213–223). This procedure was used to determine the degree of association between the variables and the level of significance. The reported associations were significant at the 0.05 level.

All indices of habitat utilization were significantly correlated with one another, and all variables except number of beds were significantly correlated with elevation. An increase in trails was associated with a decrease in snow depth and wind velocity, and surprisingly with an increase in snow-depth variability. Because deer often selected shallow patches of snow for movement, high variability was probably an asset. Increased numbers of trails were also directly correlated with increased evergreen and total basal area and canopy cover. Deer seemed to avoid areas where the amount of deciduous cover was high. Association of bedding sites with the variables measured followed a pattern similar to the one described for trails, except that there were no significant correlations with snow conditions or elevation. The only measured weather variable with which increased numbers of beds were associated was decreased wind velocity. The other variables associated with an increase in bed counts were increases in evergreen and total basal area and canopy cover, and decreases in deciduous canopy cover. Increased numbers of pellet groups were associated with increases in evergreen and total basal area and canopy cover and with decreases in wind velocity and snow depth. Based on pellet-group counts, deer were not associated with deciduous cover, either positively or negatively.

The measured weather variables appeared to be affected by an increase in the proportion of evergreen-to-deciduous basal area and cover which was related to a decrease in elevation. Higher proportions of evergreen cover also occurred with increased total basal area and canopy cover. Wind velocity decreased with an increase in evergreen and total basal area and canopy cover and increased with an increase in deciduous canopy cover. An increase in snow depth and a decrease in snow-depth variability was also associated with increased wind velocity. Snow depth was significantly correlated only with wind velocity. Snow-depth variability increased with an increase in evergreen and total basal area and canopy cover and decreased with an increase in deciduous canopy cover and wind velocity. At higher elevations, where winds blew unimpeded by evergreen cover, snowfall was uniformly deep. At lower elevations, especially near the stream, snow depths were less and snow-depth variability was greater apparently owing to a combination of interception by evergreen canopy cover and passage through pockets of deciduous cover and/or the more open canopy at the stream. Snow depths could also have been more variable at the stream owing to increased wind velocity causing some drifting.

Habitat Types

The three habitat types found within the deer wintering area differed both in overstorey and understorey species composition and structure (Table 1). Eastern Hemlock and Sugar Maple dominated the habitat on the northeast-facing slope, making up 82.9% of all individual species and 84.8% of the basal area. On the southwest-facing slope, these two strata were dominated by Sugar Maple, comprising 37.4% of all individual species and 55.0% of the basal area. Red Oak was also an important species with 22.1% of the basal area. Many of the oaks were large, mast-producing trees (> 41.5 cm dbh). The bottomland was dominated by Eastern Hemlock and Yellow Birch. These species made up 53.2% of all individual species and 44.9% of the basal area. Red Maple and Red Oak increased the relative density and basal area to 59.8 and 70.2%, respectively.

Differences in the species composition and structure of the ground-layer stratum among the three habitat types resulted in different amounts and quality of food available to the wintering deer herd (Table 2). The ground-layer stratum on the northeast-facing slope (Eastern Hemlock – Sugar Maple) was composed primarily of Sugar Maple and Black Cherry. In the winter, the major browsable species (⩾50 cm in height, ⩽1.5 cm dbh) available for browsing were American Beech, Striped Maple (*A. pensylvanicum*), and Sugar Maple. Beech and Sugar Maple were the most heavily browsed species. On the southwest-facing slope (Sugar Maple), the ground-layer stratum was dominated by Red Oak, Sugar Maple, Black Cherry, and American Beech. In winter, the common species for browse were American Beech and Black Cherry. Black Cherry showed signs of receiving some use. The most common species on the bottomland (Eastern Hemlock – Yellow Birch) was Rosebay Rhododendron, which comprised 32.9% of all species. Three evergreen species, Rosebay Rhododendron, Mountain Laurel (*Kalmia latifolia*), and Eastern Hemlock, made up 56.4% of all species. The major browse species in the winter were Rosebay Rhododendron, American Beech, Eastern Hemlock, and Mountain Laurel, all of which showed signs of heavy use.

The bottomland, which provided primary shelter

TABLE 1—Density (stems·ha^{-1}) and basal area ($m^2 \cdot ha^{-1}$) (B.A.) of woody plant species composing the understorey ($\geq$ 1.5–21.5 cm dbh) and overstorey ($>$ 21.5 cm dbh) strata of habitats in the Blandy Run deer wintering area

	Eastern Hemlock – Sugar Maple[a]				Eastern Hemlock – Yellow Birch[b]				Sugar Maple[c]			
	Understorey		Overstorey		Understorey		Overstorey		Understorey		Overstorey	
	Density	B.A.	Density	B.A.	Density	B.A.	Density	B.A.	Density	B.A.	Density	B.A.
Tsuga canadensis	370	1.923	103	15.201	1283	9.313	81	5.573	56	0.326	8	1.303
Populus grandidentata	—	—	—	—	10	0.251	40	2.078	—	—	—	—
Carya glabra	28	0.389	9	1.056	—	—	—	—	24	0.261	—	—
Corylus americana	—	—	—	—	10	0.005	—	—	—	—	—	—
Betula lenta	9	0.005	—	—	20	0.128	10	0.415	—	—	—	—
B. lutea	19	0.009	—	—	102	1.433	70	5.374	—	—	—	—
Fagus grandifolia	93	0.328	9	0.793	444	1.238	20	1.664	715	1.844	—	—
Quercus alba	—	—	—	—	—	—	—	—	—	—	8	0.679
Q. rubra	—	—	—	—	—	—	20	5.610	16	0.209	16	5.831
Magnolia acuminata	—	—	9	1.694	—	—	—	—	—	—	—	—
Hamamelis virginiana	9	0.019	—	—	—	—	—	—	8	0.004	—	—
Amelanchier arborea	—	—	—	—	253	2.636	—	—	—	—	—	—
Prunus serotina	28	0.699	9	0.919	70	0.752	30	2.732	48	0.430	8	0.326
Acer saccharum	528	5.846	121	10.072	101	1.147	—	—	461	3.884	143	11.152
Acer pensylvanicum	9	0.005	—	—	—	—	—	—	8	0.016	—	—
Acer rubrum	—	—	—	—	131	0.512	40	6.112	72	1.029	—	—
Cornus florida	—	—	—	—	—	—	—	—	24	0.048	—	—
Rhododendron maximum	—	—	—	—	121	0.076	—	—	—	—	—	—
Kalmia latifolia	—	—	—	—	10	0.005	—	—	—	—	—	—
Fraxinus americana	—	—	—	—	—	—	20	1.280	—	—	—	—
Total	1093	9.223	260	29.735	2555	17.496	331	30.838	1432	8.051	183	19.291

[a]Computations are based on twelve 90-m^2 sample plots.
[b]Computations are based on eleven 90-m^2 sample plots.
[c]Computations are based on fourteen 90-m^2 sample plots.

and food for the wintering deer herd, had a greater variety of species than the other two habitat types. There, density and basal area of the overstorey and understorey were greater than that of the other two habitat types. Eastern Hemlocks composing the ground-layer and understorey strata were especially dense. On the bottomland, evergreen species comprised 51.8% of all species; in contrast, on the northeast- and southwest-facing slopes, they comprised only 35.0 and 3.9%, respectively.

Discussion

Of the three indices of habitat utilization, the number of beds provided the best means of assessing areas of protective cover. High trail counts were not necessarily associated with time spent in an area or utilization. Although trail counts were high at the stream, bed and pellet-group counts were low. Based on this information, deer apparently spent little time at streamside. In places where the stream was ice-free, deer undoubtedly used it as a water source, but the high trail counts at the stream probably resulted from individuals quickly crossing from one area of protective cover to another. Pellet-group counts were also related somewhat to foraging areas rather than solely to protective cover.

High numbers of beds were found most often on the bottomland of Blandy Run, but never adjacent to the stream. Bedding areas were characterized by the highest evergreen and total basal area and cover values. But wind velocities appeared to influence choice of bedding sites directly, and could explain why deer failed to bed in the bottomland near the stream. The stream was oriented in the direction of prevailing winds, and winds probably funneled down the stream valley almost unobstructed by vertical evergreen cover. The resulting increase in wind chill is believed to have encouraged deer to bed in the densest evergreen cover away from the stream. Robinson (1960), studying shelter requirements of penned White-tailed Deer in Maine, found that deer survived equally well in sparse, moderate, and dense coniferous cover because they selected bedding sites with similar microclimates. In his study, a typical site had dense conifers overhead, trunks of trees or slash to the north, and a southern exposure. Bedding sites were

TABLE 2—Density (stems·ha^{-1}) by height class of woody plant species composing the ground-layer stratum of habitats in the Blandy Run deer wintering area

	Eastern Hemlock – Sugar Maple[a]		Eastern Hemlock – Yellow Birch[b]		Sugar Maple[c]	
	< 50 cm in height	⩾ 50 cm in height, ⩽ 1.5 cm dbh	< 50 cm in height	⩾ 50 cm in height, ⩽ 1.5 cm dbh	< 50 cm in height	⩾ 50 cm in height, ⩽ 1.5 cm dbh
Tsuga canadensis	—	37	6061	364	—	—
Carya glabra	278	—	—	—	—	—
Betula lenta	—	—	—	—	—	127
B. lutea	—	—	6212	—	—	—
Fagus grandifolia	1250	407	4394	768	1190	1778
Quercus alba	—	—	—	—	952	—
Q. rubra	1389	—	1818	40	9524	32
Magnolia acuminata	—	—	152	—	119	—
Hamamelis virginiana	—	74	—	40	—	—
Amelanchier arborea	—	—	2576	—	—	—
Crataegus sp.	—	—	152	—	—	—
Prunus serotina	10 833	—	6515	40	6667	1270
Acer saccharum	14 861	222	—	—	8333	63
Acer pensylvanicum	139	259	455	—	—	—
Acer rubrum	—	—	1364	—	238	—
Cornus florida	—	—	—	—	119	—
Rhododendron maximum	—	—	16 061	2424	—	—
Kalmia latifolia	—	—	6515	323	—	—
Sambucus pubens	139	—	—	—	—	—
Total	28 889	999	52 275	3999	27 142	3270

[a]Stems·ha^{-1} based on twenty-four 3-m^2 and twelve 22.5-m^2 sample plots for the < 50 cm height class and ⩾ 50 cm, ⩽ 1.5 cm dbh height class, respectively.
[b]Stems·ha^{-1} based on twenty-two 3-m^2 and eleven 22.5-m^2 sample plots for the < 50 cm height class and ⩾ 50 cm, ⩽ 1.5 cm dbh height class, respectively.
[c]Stems·ha^{-1} based on twenty-eight 3-m^2 and fourteen 22.5-m^2 sample plots for the < 50 cm height class and ⩾ 50 cm, ⩽ 1.5 cm dbh height class, respectively.

seemingly chosen for their protection from wind and slightly warmer temperatures, especially during periods of cold weather. Temperatures under thick conifer cover are known to have the narrowest thermal ranges and warmest mean temperatures (Ozoga 1968). Moen (1968a, b) has also shown that radiant and convective heat loss from deer is minimized under dense conifer cover. Surprisingly, deer at Blandy Run selected bedding sites without regard to snow depth, within the range of snow depths encountered in this study. In contrast, Huot (1974) found that deer tended to bed in areas of lesser snow depths within conifer stands in Quebec. Moen (1976), however, has indicated that bedding in deep snow may afford some insulation and reduce the effective wind velocity around the animal. The lack of significant correlation of bed counts with elevation is understandable as energetic cost, once the animal has lain down, remains the same whether the surrounding topography is flat or hilly (Moen 1976).

Of the three habitat types, the Eastern Hemlock–Yellow Birch habitat on the bottomland along Blandy Run served as the primary wintering area. Based on pellet-group counts, we estimated that about 54 deer occupied this 31 ha of prime winter habitat, or about 1.75 deer · ha^{-1}. Here, Eastern Hemlock basal area ranged from 10 to 25 m^2 · ha^{-1}, and total basal area ranged from 30 to 45 m^2 · ha^{-1}. Canopy cover of the dominant hemlocks exceeded 50%, and total canopy cover was greater than 70%. Although deer browsing was heavy on hemlock (twigs and leaves) and rhododendron (flower and vegetative buds and leaves) in certain locations, both species seemed to provide substantial browse for the wintering deer herd. Foliage and branches often extended down to the snow level within easy reach of browsing deer. The other two habitat types received proportionately less use; however, the Sugar Maple habitat type on the southwest-facing slope was used heavily on milder days. The lesser snow depths probably influenced this activity, although even here deer were never far from evergreen

cover. The southwest-facing slope, in contrast to the northeast-facing slope, also provided excellent sunning sites for the deer and a high-energy food source, the bumper fall acorn crop. Here, many cratering areas were located near seeps where snow depths were much less than elsewhere. Based on the accumulation of pellet groups, we assumed that deer spent some time at these sites taking advantage of the food source, lessened snow depths, and increased solar radiation on calm cloudless days. The importance of this supplemental food source should not be underestimated, as it undoubtedly helped to keep the herd in good condition throughout the winter. Although evergreen cover was available in the Eastern Hemlock – Sugar Maple habitat type on the northeast-facing slope, deer seemed to avoid the upper part of this habitat type, possibly because of deep snow conditions and few browse stems. Here, mean snow depths exceeded the critical 40-cm depth reported by Kelsall (1969) to impair deer movement considerably. The snow was so soft that deer were observed to sink nearly to ground level.

In conclusion, White-tailed Deer within the Blandy Run wintering area seemed to respond to microspatial differences in weather. These microhabitat differences were apparently related to the proportion of evergreen to deciduous canopy cover and to topographic position.

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Radio-tracking of Moose in the Boreal Forest of Northwestern Ontario[1]

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Movements of eight Moose (*Alces alces*) equipped with radio-transmitter collars were followed by airplane flights at approximately weekly intervals between July 1972 and June 1973, in boreal forest of northwestern Ontario. Two adults and one yearling made migrations of 2–13 km linear distance between a mid- and late winter range, and a second range used at other times of the year. These animals occupied ranges of 2–12 km^2 in winter, and 6–90 km^2 in other seasons. Another adult used an area of 14 km^2 during the year, with adjacent winter and non-winter range. Two adults used areas of 10–14 km^2, but winter tracking was incomplete. Two yearlings showed large movements, and one dispersed over a distance of 25 km. Most of the Moose alternated between periods of wide-ranging movements and periods of localized movements. Most animals moved to conifer-dominated winter range in December or January, near the time when snow-cover thickness increased rapidly to about 50 cm.

Key Words: Moose, *Alces alces,* movements, migration, dispersion, home range, habitat, radio tracking, snow, boreal forest.

Information on Moose movements in the boreal forest is extremely limited (Van Ballenberghe and Peek 1971), although good studies have been done in other types of habitat (e.g., LeResche 1972; Phillips et al. 1973). From results of earlier studies in Ontario it became apparent that the use of ear tags was providing only limited information on Moose movements (Goddard 1970; Saunders and Williamson 1972). Accordingly a radio-tracking study was conducted to provide more complete information on movements and habitat use than that provided by conventional aerial survey or ground observations.

Study Areas

The two study areas consist of boreal forest on flat lowland to rolling upland sites ranging between 360 and 460 m asl (Figure 1). The areas are dominated by coniferous forest on swamp, moist or upland sites, with some mature White Birch (*Betula papyrifera*) and Trembling Aspen (*Populus tremuloides*) present, and an upper canopy ranging from open to relatively closed. Other vegetation communities present, roughly in order of percentage occurrence, are pure stands of Black Spruce (*Picea mariana*) on upland and lowland sites, wet treed bog and thicket with dwarf or immature Black Spruce, ridge tops and scattered rock outcrops with a sparse growth of trees, untreed wetlands, and mature mixed forest. The Lac Seul area also contains a large tract of land burned in 1961. The burn is dominated by abundant regeneration of deciduous species, dense stands of immature Jack Pine (*Pinus banksiana*), open mixed forest, and mature unburned Black Spruce on wet sites. No significant logging has occurred. Both study areas contain numerous small lakes and wetland areas. The Lac Seul area is bordered to the south by Lac Seul, a reservoir of about 1300 km^2 surface area.

Weather records were compiled from the stations nearest to the study areas (Figure 1). Mean daily temperature, based on averages between 1941 and 1970 (Atmospheric Environment Service, no date), ranged from monthly highs of 16–17°C in July and August to lows of −19 to −20°C in January. Annual precipitation averaged 60–75 cm. In most winters, snow began to accumulate in early November and reached a maximum depth of 70–85 cm in late March. During the year of study, all stations recorded a cold December (−19 to −20°C), a warmer January (−14 to −15°C), and an unusually rapid accumulation of snow of 20–25 cm in mid-December to 50–55 cm by the first week of January, with little further accumulation during the remainder of the winter (Ontario Ministry of Natural Resources, unpublished records).

[1]Ontario Ministry of Natural Resources, Wildlife Research Contribution Number 79-21. Requests for reprints should be sent to last author.

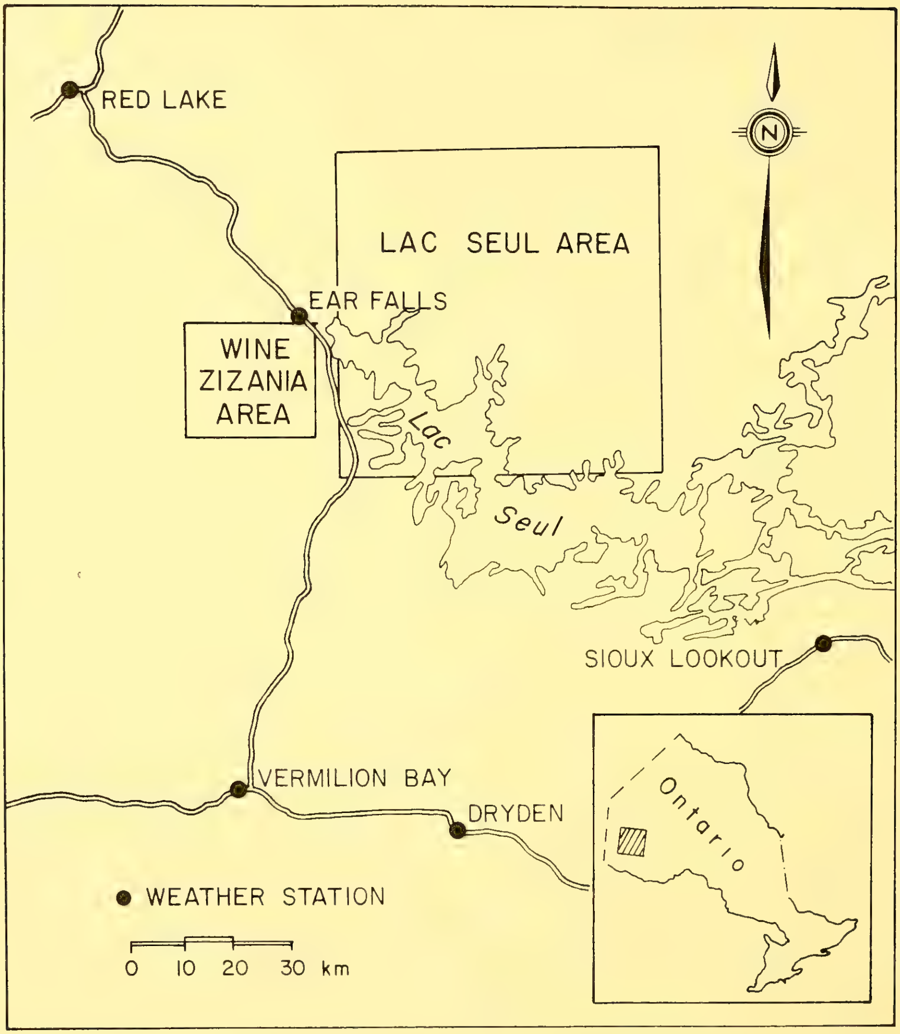

FIGURE 1. Location of the Wine-Zizania (50° 30′N, 93° 23′W) and Lac Seul (50° 40′N, 92° 40′W) study areas, and of the five weather stations.

Methods

Radio collars consisted of a two-stage transmitter and four D-size Mallory ZM 12 mercury batteries encased in a fiberglass canister with a leather covering (Addison 1973). Two brass strip antennae encased in leather formed a collar of adjustable length with a snap fastener. Each transmitter had a different emission frequency and pulse rate.

Collars were attached to five adult females, three adult males, three yearling females, and two yearling males, during 28 h of helicopter flying between 24 June and 15 July 1972, using a method similar to that of Simkin (1963). Yearlings were identified by the size and appearance of the body and antlers, as described by Goddard (1970) and subsequently confirmed by Saunders and Williamson (1972). The collar was attached to one antler on Moose number 7 (M7), a large adult bull, because it was too small for the animal's neck.

Animals were located from the air during 41 flights in a Turbo-Beaver aircraft between 14 July 1972 and 13 June 1973, usually between 10:00 and 14:00. A modified Cochran receiver (Cochran and Lord 1963) was used, with a whip antenna during the first four

flights, and a 10-element 2-m Yagi antenna in the remaining flights. Most flights were made at intervals of 6–8 d, with 3 and 16 d representing extreme cases. At the time of flight 1 (14 July) several of the Moose had not yet received collars. Flights 2 and 31 (20 July and 21 March) were done only for the Lac Seul area, and flights 12, 29, and 33 (11 October, 5 March, and 8 April) only for the Wine-Zizania area.

The flights were typically 4.5 h duration for the two study areas combined. Intensive searching usually began where one of the animals had been located on the previous flight. If the animal was not detected immediately, a series of widening circles was made at an altitude of 200–250 m over a radius of 2 km from the starting point. Subsequent searching, when necessary, consisted of flying along waterways and ridges at a maximum altitude of 650 m. This was typically done over a radius of 3–5 km from the starting point, but digressions of up to 16 km were made on occasion.

Throughout the flight the radio receiver was set to scan the transmission frequencies of all 13 collars, and both the pilot and observer monitored the receiver during most of the flight. When a signal was detected, the area was flown in a series of circles. The animal's position was determined on the basis of signal strength with the gain control of the receiver set at a low level. The location of a Moose was marked on a 1:250 000 topographical map. On several occasions the animals were observed, and on three occasions a transmitter which had fallen or was attached to a dead animal was recovered on foot after being located from the aircraft.

Tracking was also completed by triangulation of bearings received at two fixed radio towers in the Wine-Zizania area. Successful tracking was largely confined to three Moose during parts of the first 3 mo of study with some tracking at all times of day. The results will be reported separately, but are mentioned here because they give some information about movements between weekly aircraft searches.

Results

Five of the 13 Moose were not located after October or November. One Moose lost its collar, one died, and three cases of transmitter failure were suspected. Data for these animals were omitted from analysis. Data derived from the remaining animals are given in Table 1. The movements of these Moose followed three different patterns.

1) Three Moose migrated between a small range used exclusively in the winter, and a larger area used at other times of the year. For example M8, an adult male, used a winter range of 12 km^2 (calculated approximately by joining outer locations to form a convex polygon) between 10 January and 18 April, and a 90-km^2 non-winter range 6 km to the north (Figure 2). Details for the other migratory Moose are given in Table 2. For M4 and M8, the distance between successive locations was smaller on the winter range than at other times of the year ($P < 0.02$ by Student's t test after logarithmic transformation of the data).

2) One Moose (M13, an adult female) did not use a winter area which was clearly separated from the rest of the annual range (Figure 3). Between 13 December and 5 March, M13's locations were concentrated in the more southern part of its range, but the mean ± SE distance between locations was not substantially smaller during this period (1.3 ± 0.4 km) than at other times (1.6 ± 0.3). The animal's annual range consisted of 14 km^2.

3) Two Moose, both of them yearlings, had periods of localized activity alternating with long "wandering" movements covering areas to which the animal did not

TABLE 1—Moose number, age and sex class, tracking period, number of successful and unsuccessful attempts to locate the animal, and mean (± SE) distance between successive locations, for eight Moose on two study areas

Moose number	Age and sex		Tracking period	Number of locations	Unsuccessful attempts	Distance (km)
Lac Seul area						
M2	Yearling	♀	9 Aug.–13 June	26	8	4.8 ± 1.3
M4	Yearling	♂	20 July–6 June	27	9	3.2 ± 0.7
M8	Adult	♂	20 July–13 June	34	3	4.3 ± 0.6
Wine-Zizania area						
M6	Adult	♀	26 July–13 June	28	10	1.6 ± 0.2
M7	Adult	♂	26 July–21 Feb.	25	0	1.0 ± 0.2
M12	Adult	♀	26 July–13 June	36	2	1.3 ± 0.1
M13	Adult	♀	3 Aug.–12 April	30	0	1.5 ± 0.2
M16	Yearling	♀	14 July–18 April	23	10	1.9 ± 0.5

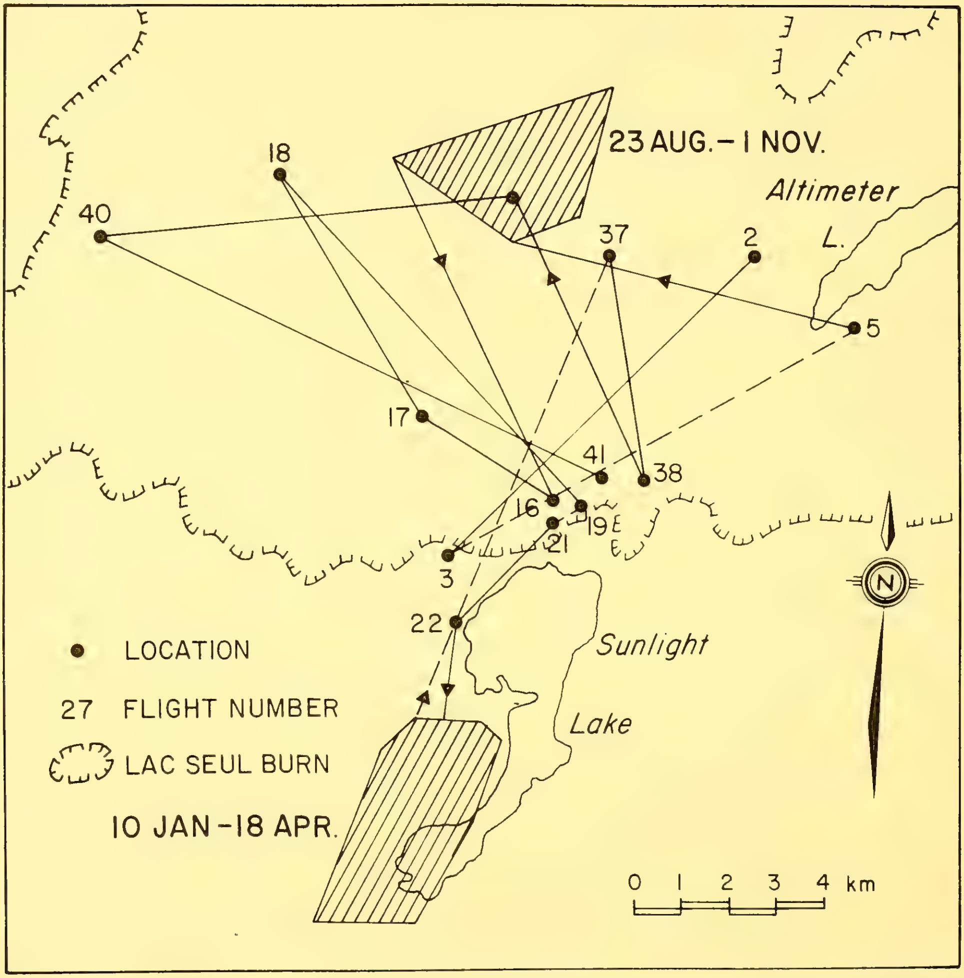

FIGURE 2. Locations of M8, an adult bull in the Lac Seul area. Localized ranges were used between 23 August and 1 November (flights 6 to 15), and between 10 January and 18 April (flights 23 to 35). Broken lines indicate that the animal could not be found during one or more flights between successive locations.

TABLE 2—Dates of use of winter range, size of range, and distance (mean ± SE) between successive locations for winter and non-winter ranges, and distance between the two ranges, for the three Moose which used a winter range separate from areas used at other times

		Winter range		Non-winter range		
Moose	Dates	Size of range (km^2)	Distance between locations (km)	Size of range (km^2)	Distance between locations (km)	Distance between ranges (km)
M4	10 Jan.–27 Mar.	3	1.3 ± 0.3	32	4.0 ± 0.8	13
M8	10 Jan.–18 Apr.	12	2.2 ± 0.5	90	5.2 ± 0.7	6
M12	23 Jan.–18 Apr.	2	0.9 ± 0.1	6	1.4 ± 0.2	2

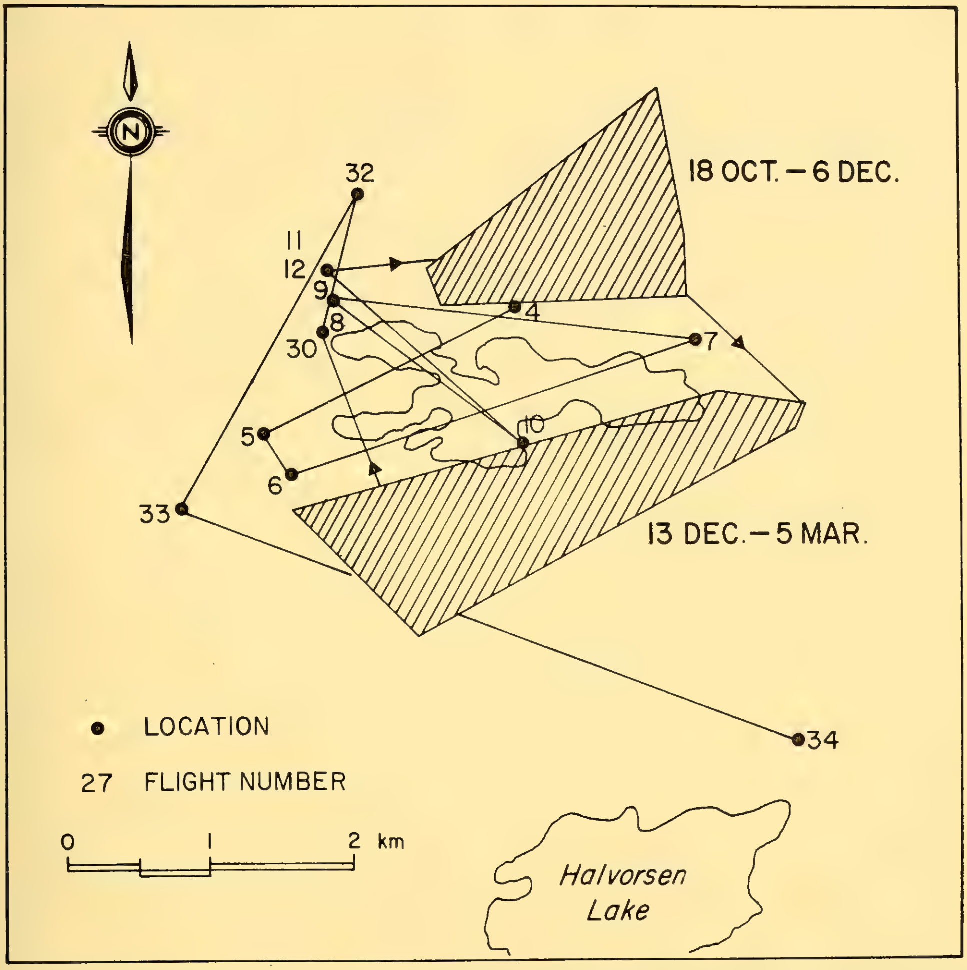

FIGURE 3. Locations of M13, an adult female in the Wine-Zizania study area. Movements were somewhat localized between 18 October and 6 December (flights 13 to 19), and between 13 December and 5 March (flights 20 to 29).

subsequently return. For example, M2 was found several times near the north end of the Lac Seul burn in September, moved 30 km to the southwest by 24 November, and moved 17 km east to a winter range of 4 km^2 occupied between 19 December and 27 March (Figure 4). M16 remained in a 4-km^2 area between 14 July and 13 December, and then ranged widely. It was found on only four subsequent flights between January and April, in widely separated locations up to 10 km from its small original range.

For the remaining two Moose, winter tracking data were inadequate. M6 was not found between 21 February and 8 April, perhaps because it had moved to a winter range which was never found by the observers. Tracking of M7 ended in February after the transmitter was lost when the antlers were shed. Based on successful locations, we found ranges to consist of 14 and 10 km^2 for the M6 and M7, respectively.

Habitat was classified with the aid of 1:15 840 aerial photographs. All three Moose in the Lac Seul area (M2, M4, and M8) spent some time in the Lac Seul burn, but they all moved to winter ranges in areas of Black Spruce swamp outside the burn. The one distinct winter range in the Wine-Zizania area, used by M12, was a gently rolling area with an open upper canopy of Trembling Aspen and a dense understory of immature coniferous trees.

In addition to the use of winter ranges, some Moose had periods of limited movement in small areas at other times of the year. For example, M8 was found at

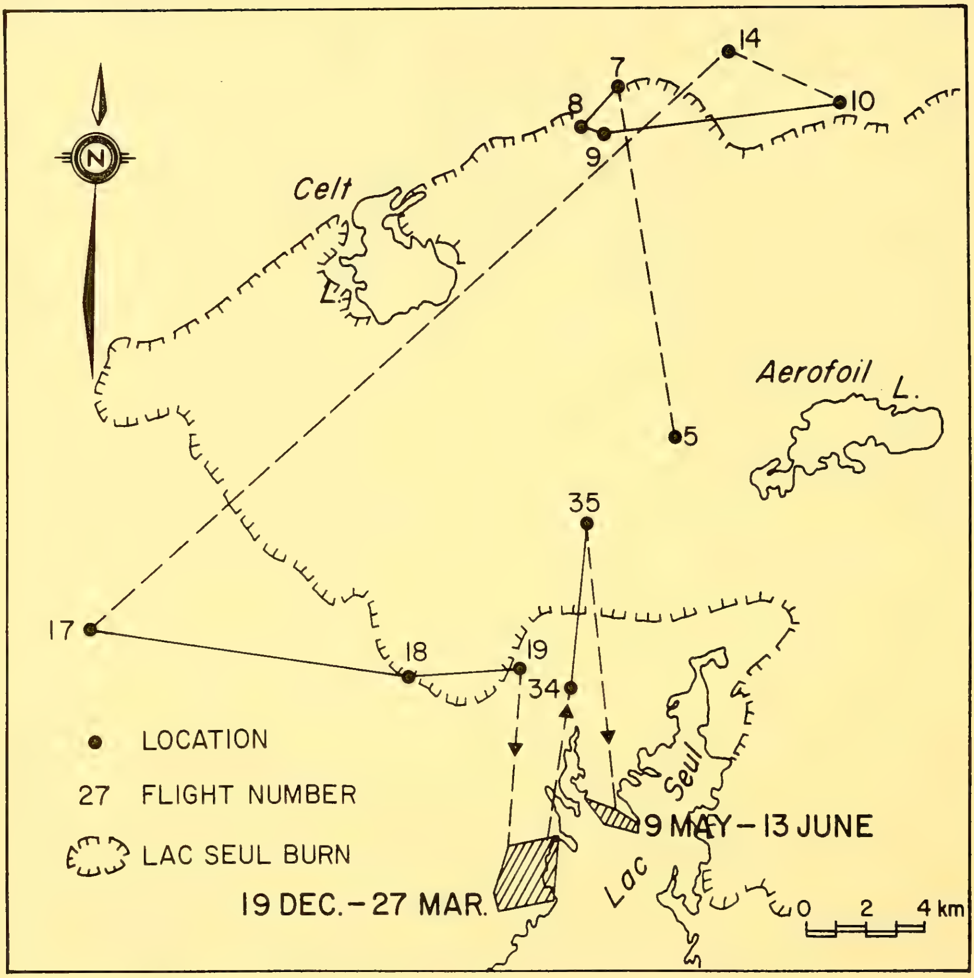

FIGURE 4. Locations of M2, a yearling female, in the Lac Seul study area. The Moose was found several times at widely separated locations, then wintered in an area of 4 km² near Lac Seul between 19 December and 27 March (flights 21 to 32). After additional movements, it remained in a second small area between 9 May and 13 June (flights 37 to 41).

TABLE 3—Dates of use, size of range, and brief habitat description for the seven localized ranges used at times other than mid- to late winter

Moose number	Dates	Size of range (km²)	Habitat
M6	23 Aug.–25 Oct.	1.5	Rolling area of mature and semi-mature coniferous trees
M8	23 Aug.–1 Nov.	8.2	10-yr-old burn with deciduous and Jack Pine regeneration
M4	20 Sept.–15 Nov.	3.7	Mainly conifer swamp
M13	18 Oct.–6 Dec.	1.7	Rolling area with mainly coniferous trees
M6	15 Nov.–13 Dec.	1.3	Rolling area with mixed coniferous and deciduous trees
M12	24 Nov.–10 Jan.	1.1	Black Spruce swamp
M2	9 May–13 June	0.8	Low-lying area with mixed coniferous and deciduous trees

the north end of its range on all eight flights between 23 August and 1 November (Figure 2). Other examples are shown in Figures 3 and 4. Table 3 lists the occasions when a Moose was found five or more times in succession in the same portion of its range, suggesting localized movement. Moose were particularly easy to find during these periods of apparently localized movement. While using the four distinct winter ranges and the other localized ranges listed in Table 3, the animals were located 98 times with two unsuccessful attempts. In the rest of the tracking period, the same six animals were located 83 times with 30 unsuccessful attempts.

Discussion

Three Moose in this study migrated between a distinct winter range and a second range used at other times of the year, but other animals did not. This variation, and the short migratory distances involved, are similar to the findings of Phillips et al. (1973) for an area of marsh, willow flats, and forest in northwestern Minnesota, but they contrast with the longer migrations seen in some mountainous areas (LeResche 1974).

Differences between Moose in the tendency to migrate may be related to the degree of interspersion of different habitat components (LeResche 1974). The three Moose in the Lac Seul area spent part of the year in the large burn, but moved to areas of Black Spruce swamp outside the burn in the winter. These animals also had larger distances between successive locations than the Moose in the Wine-Zizania area. A shortage of coniferous cover or other important habitat components in the burn may have caused the Moose there to be more mobile and migratory. The one clearly non-migratory moose (M13) was in the Wine-Zizania area. It wintered in an area with coniferous cover, adjacent to the range used at other times.

The use of coniferous areas in mid- to late winter is similar to the findings of Telfer (1968), Peek (1971), Van Ballenberghe and Peek (1971), Eastman (1974), and Peek et al. (1976). The movement to winter range, which occurred in December and January, was earlier and more synchronous than the pattern observed on other ranges. In mountainous areas the migration to lowlands is often a gradual process which continues throughout the winter (Edwards and Ritcey 1956; Stevens 1970), although LeResche (1974, p. 400) cites an exception from Alaska. In non-mountainous areas patterns of movement are less clear, but aerial Moose surveys in Ontario generally show a gradual disappearance of Moose from open areas between late December and March.

In the year of study, the sudden accumulation of snow to a thickness of 50 cm by early January may have caused the early and relatively synchronous retreat to late-winter cover. Peek (1971) found evidence of a gradual movement to winter habitats in one year, but a more sudden movement in a second year, corresponding to heavy snowfall in a short period. Phillips et al. (1973) and Peek et al. (1976) observed a movement to winter range when there was less than 50 cm of snow, but in other studies the change of habitat coincided with greater accumulation (Telfer 1968; Prescott 1968).

In addition to the use of localized range in mid- to late winter, different Moose had sedentary periods in various types of habitat at various times of the year. A similar finding was reported by Phillips et al. (1973, p. 272). For one adult cow (M6) and one adult bull (M8), a period including the rut was spent in a localized area. Three adult females (M6, M12, M13) spent the early winter in localized areas which included substantial coniferous vegetation.

The wide-ranging movements of two of the three yearlings are consistent with other studies reporting large movements by young Moose (Goddard 1970; Roussel et al. 1975; Lynch 1976). Perhaps yearling Moose disperse into new areas more readily than adults. Peek (1974) noted that young Moose in particular moved into newly-created favorable habitat after a forest fire. Yearling M2 dispersed from a very lightly hunted area to the borders of Lac Seul where heavy hunting had presumably depleted the previous population.

The results of this study do not show the full range of movements of the animals. The Moose were almost always located successfully when they were using small, localized ranges, but were frequently missed at other times. This suggests that most of the failures to find an animal were the result of inadequate searching, not temporary technical difficulties with equipment. In addition the limited amount of ground tracking, with fixes at 30- and 60-min intervals, suggested that Moose ranged more widely than weekly aerial tracking indicated. Future work of this type should include a more wide-ranging search pattern and more frequent flights.

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Hill's Oak (*Quercus ellipsoidalis*) in Canada

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Maycock, Paul F., Daniel R. Gregory, and Anthony A. Reznicek. Hill's Oak (*Quercus ellipsoidalis*) in Canada. Canadian Field-Naturalist 94(3): 277–285.

Hill's Oak (*Quercus ellipsoidalis*,) a tree of the midwestern prairie-forest border is confirmed as present in the tree flora of Canada. The occurrence of this tree at Oak Point at the south end of Lake of the Woods, Rainy River District, Ontario, marks the northwestern limit in North America. The Bur Oak – Hill's Oak (*Quercus macrocarpa – Q. ellipsoidalis*) forest in which it was discovered as an important dominant has also never been recorded in Canada and is described both quantitatively and qualitatively. The known range of Black Cherry (*Prunus serotina*) is extended 282 km northwestward. As well, a number of other interesting plants were present and their known geographical distributions in Canada are now extended.

Key Words: Hill's Oak, *Quercus ellipsoidalis*, Bur Oak – Hill's Oak forest, new records, plant range extensions, Rainy River District, Black Cherry, *Prunus serotina*.

The discoveries which resulted from the extensive field studies of John Macoun (1886) and associates in the closing decades of the last century were probably the last that resulted in any increase in the list of trees in the Canadian flora. Few of the native plant communities, however, have yet been formally described and fewer have been quantitatively defined.

In recent periods publications concerned with the floras of regions adjacent to Ontario have become available and include Michigan (Voss 1972), northeastern Minnesota (Lakela 1965), and Manitoba (Scoggan 1957). The range descriptions and maps for many species of plants in these regions indicate that a number are found in close proximity to Ontario and yet have not been recorded from the province. There is high probability that additions to the Ontario flora may be made if these specific plants were sought in the appropriate ecological environments in neighboring localities.

This assumption was tested during field studies concerned with phytosociological investigations of the forests of the southwestern sector of northwestern Ontario during August 1975. New plant records were found during the course of these investigations, particularly the discovery of a species of oak not previously known in the province or in Canada. A quantitative study was made of the forest community which includes this oak and it was discovered that other plants not previously reported for this northwestern region were also included.

This contribution notes the presence and distribution of Hill's Oak in Canada, documents the presence and distributions of the other plants, and attempts to clarify their range extensions. It also presents a detailed quantitative description of the forest community.

Study Area

The region concerned is the southwestern section of the Rainy River District along the shores of Rainy River near its mouth as it enters the south end of Lake of the Woods (Figure 1). It has been described and mapped by Rowe (1972) as Great Lakes – St. Lawrence forest. A number of Great Lakes forest elements such as *Pinus strobus* (White Pine), *Pinus resinosa* (Red Pine), *Thuja occidentalis* (White Cedar), *Fraxinus nigra* (Black Ash), and *Ulmus americana* (White Elm) are either found throughout the area or confined to southern sections; however, such species occur sporadically or are restricted to specialized sites. The overall regional forest vegetation is strongly boreal. *Picea mariana* (Black Spruce) is the predominant species in lowland sites as well as on moist uplands, and *Pinus banksiana* (Jack Pine) is the major tree species on well drained uplands. *Populus tremuloides* (Trembling Aspen) and *Betula papyrifera* (Paper Birch) are important trees of broad moisture tolerance and are significant in the fire succession cycle which is so integral a part of the regional ecological picture. Although Bur Oak (*Quercus macrocarpa*), Red Oak (*Q. rubra*), and the Hill's Oak are present, they are so confined in their occurrence that they do nothing to change this regional pattern of the forest vegetation.

Within the specific area considered there are extensive low-lying clay plains which were deposited in the bed of glacial Lake Agassiz. The relief is low and the topography is decidedly flat. On slightly higher ground where some drainage is possible, there are extensive stands of aspen reminiscent of areas in the central Ontario Clay Belt. The low poorly drained ground, particularly extensive tracts adjacent to the Lake of the Woods, is occupied by sedge and grass meadows, many of which have a distinct prairie

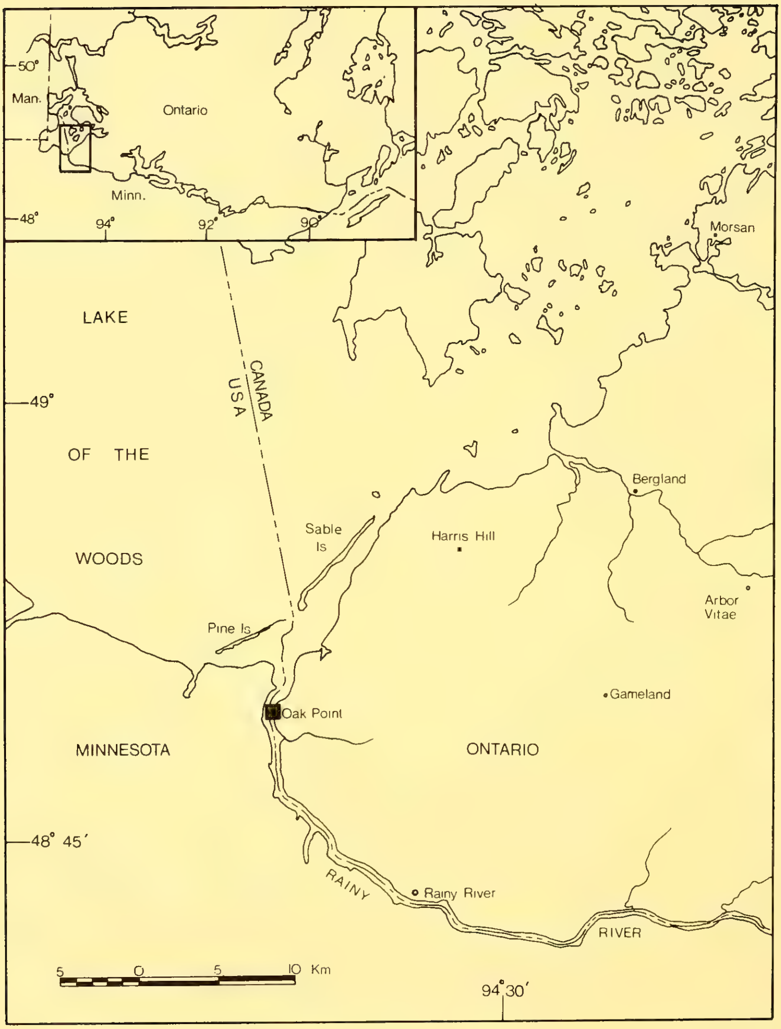

FIGURE 1. Map of the extreme western section of Rainy River District, Ontario showing the location of the Oak Point stand of *Quercus ellipsoidalis*.

aspect. The presence of plants of western affinity is also strong in other open communities such as pine barrens, oak savannas, and river shores. Western and southern faunal elements have also been well documented by the field studies of Snyder (1953).

On the broad sand plain that comprises Oak Point in Wildland Township, along the Rainy River just south of Lake of the Woods, the unique forest was noted. The site was influenced by a warmer than normal microclimate being in close proximity to the river and the extensive lake mass, and was dominated by species of deciduous trees and appeared physiognomically similar to the broad-leaved forests found throughout much of southern Ontario. The striking feature of this forest was not its non-boreal physiognomy, but rather that in a region so far north in Ontario, it was dominated by oaks.

Methods

The forest was studied to judge its extent and homogeneity. The point quarter method of forest survey (Curtis 1959) was used for sampling. This briefly, involves the selection of random points throughout homogenous stands. At each point the forest is divided into four quadrants, within each of which the nearest tree (≥ 77 cm^2 basal area breast height), its

species, basal area at breast height, and distance from the point, is recorded as well as the species and distance of the nearest sapling (≥ 2.5 cm in diameter). At every other point, the ground vegetation is sampled in metre-square quadrats to obtain frequency values. All vascular plants including tree seedlings (< 2.5 cm in diameter) present in the stand are listed. Importance values based upon the sum of relative frequency of occurrence of trees at points, relative density of trees counted at points, and relative basal areas contributed by all trees of a species, are calculated to provide quantitative expression of all tree species in the community as a whole. Structural, compositional, and environmental features are also noted. In this specific study a total of 30 points was sampled.

Specimens collected at the site have been deposited in the Herbarium, University of Toronto (TRT), and duplicates have been distributed to the Erindale College Herbarium (TRTE), the National Herbarium (CAN), and the Biosystematics Research Institute Herbarium (DAO).

Results

Oak-dominated forests have been noted in northwestern Ontario (Halliday 1937; Rowe 1972) and are essentially limited in their distribution to areas in close proximity to Lake of the Woods and to the shores of lakes and rivers emptying into it. Oaks may occur in other localities in the region but do not form stands, being restricted as individuals or as scattered small groupings in very specific environmental situations. Oak sites are so rare that in the course of forest studies during two summers, only five stations for oak communities were noted. As well, most oak stands in the region were found as savannas composed of gnarled open-grown trees with either heavy shrub or shrub and grass cover beneath and in some cases the trees had been degraded to form grubs (Curtis 1959), possibly as a result of fire and/or excessive drainage conditions. The oak of most common occurrence is *Quercus macrocarpa* (Bur Oak) but *Q. rubra* (Red Oak) is exceptionally sporadic in occurrence.

Taxonomy and Distribution of the Oak Species

Despite the botanical connotation of the name Oak Point, it was unusual to find well developed Bur Oak forest occupying an extensive area of more than 8 ha. In an attempt to identify another oak which was the second dominant in the stand and which initially had been suspected to be *Q. rubra*, it was noted that the dark bark was strongly fragmented into squarish plates and that the crown and leaf features were reminiscent of Pin Oak (*Q. palustris*). This species was impossible for the region being separated geographically from other trees of this species by great distance. Good materials were required for positive identification and one of the larger trees was climbed and specimens with acorns and crown leaves exposed to the sun were obtained. These specimens clearly portrayed the shiny, very deeply lobed glabrous leaves (Figure 2), the pubescent acorn cup scales, and the small reddish terminal buds of *Q. ellipsoidalis*, the Hill's Oak.

The leaves varied considerably in shape and size depending on position on the tree. The heavily shaded, lower leaves were larger and much more shallowly lobed than those in the crown exposed to full sunlight. The lower shade leaves were much less suitable for positive determination than the sun leaves.

Quercus ellipsoidalis has an unusual distribution for a tree considered a member of the Oak-Hickory forest. It is essentially northern midwestern being found from northwestern Ohio and adjacent southern Michigan through northern Indiana, northern Illinois, and northern Iowa, as well as throughout much of Wisconsin and adjacent Minnesota. Rather than having a center of occurrence in the Ozarks as so many Oak-Hickory forest elements do, it is essentially centered on the Driftless Area of southwestern Wisconsin. To ascertain whether other stations for the species occurred in Ontario, we made a search in important eastern Canadian herbaria for specimens. Collections in the black oak group were examined because confusion in this group may frequently happen. In the course of this search an early record for Lambton County in southwestern Ontario was reported (Mitchell 1912). The specimen on which this report was based was taken near Point Edward in 1911 by N. Tripp. It is fragmentary and appears to be Hill's Oak but cannot with certainty be verified because all the necessary structures are unavailable on the specimen. Another sheet collected by C. K. Dodge and identified by C. S. Sargent, in the Michigan herbarium as *Quercus ellipsoidalis*, is clearly not Hill's Oak, but *Quercus velutina*, the Black Oak.

Another possible record for the species is a collection of *Quercus* in the *Q. coccinea – Q. ellipsoidalis – Q. palustris* complex from Point Edward (Point Edward, St. Clair River, Ontario, Macoun, 24139, 14-IX-1884, CAN). This specimen is also difficult to determine with absolute certainty because it lacks reproductive material. It forms the basis for the record of *Quercus palustris* from Point Edward, on the map published by Fox and Soper (1954). Little (1971) has also mapped *Q. ellipsoidalis* in a restricted site in the eastern section of the Rainy River District, Ontario, adjacent to its nearest areas of occurrence in Minnesota (Lakela 1965). It is probable that the species is growing there but no herbarium specimens to support the occurrence were seen. There does seem to be every indication that this oak is also growing in southwest-

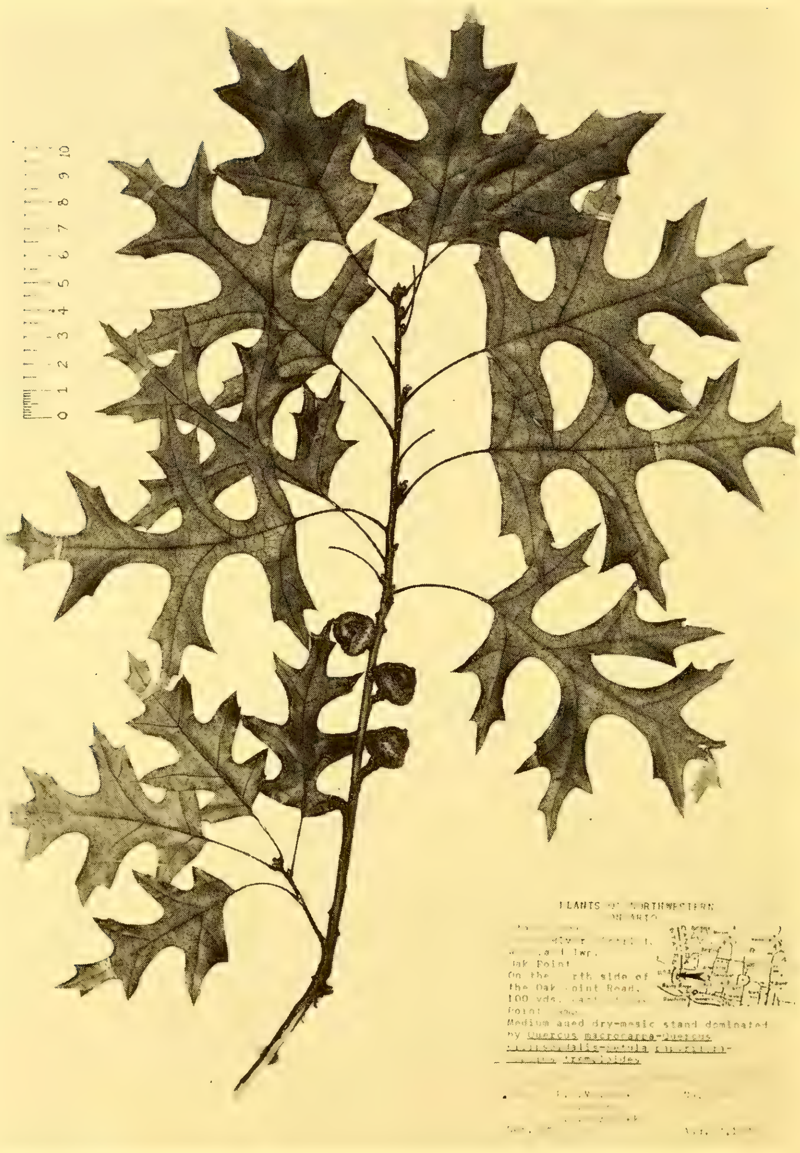

FIGURE 2. Typical crown branch of *Quercus ellipsoidalis* from the Oak Point site. Note deeply lobed leaves, small somewhat flattened inversely conical acorns, and small terminal buds of this species.

ern southern Ontario as well as in the northwestern part of the province, but verification of this will depend on more field work in this area and the collection of better materials. It is essential to have late summer or early fall collections with mature leaves and twigs, well formed buds, and with mature acorns. The verification of the presence of this oak at the Oak Point location helps to provide a solution to the consistent problems that taxonomists and field botanists have experienced in attempting to identify specimens of this difficult group in Ontario. The manuals, keys, and vegetational descriptions should now be revised in the light of this new finding.

A careful investigation of oak trees in this region as well as in southwestern Ontario, would be desirable, especially based on careful collections of sun leaves

with acorns. Much of the scant *Quercus* material in herbaria is unsatisfactory for critical determination. The Oak Point record is the most northerly occurrence in North America for this species, but represents only a modest range extension northward of approximately 42 km from the nearest known station in adjacent Minnesota.

Composition of the Oak Forest

Quercus ellipsoidalis was not a minor component in the stand but was an important contributor to the character of the forest in accounting for more than one quarter of the tree importance. The stand was also quite complex in terms of general species richness and structural components, especially for one so far north in Ontario, and in addition contained a large number of southern species.

Table 1 gives the composition of the tree canopy. The importance values sum to 300 and are the composite value of relative frequency, relative dominance, and relative density. Tree species are arranged in descending order of importance. The strong dominance of *Quercus macrocarpa* is clearly evident. *Quercus ellipsoidalis* as second dominant, and *Betula papyrifera* and *Populus tremuloides*, are the only other major contributors. The last four species listed were only observed and were not sampled at points. In all, 11 tree species occurred in the stand.

A most significant find in this forest, in addition to *Quercus ellipsoidalis* was the presence of Black Cherry (*Prunus serotina*) as a minor contributor to the forest canopy. This species has never been recorded before for northwestern Ontario (see Fox and Soper 1953), and its occurrence at Oak Point represents a sizable range extension of approximately 282 km northwestward from the nearest station in Minnesota (Little 1971; Lakela 1965).

As in the case of the tree stratum, both the sapling and seedling reproduction layers are dominated by oaks. *Quercus macrocarpa* has the greatest sapling relative density (67%) whereas all other species, including *Q. ellipsoidalis* (2%), are of lesser significance. In the seedling layer, however, the positions of the two oaks are reversed with *Q. ellipsoidalis* having a relative frequency of 55% and *Q. macrocarpa* only 17%. This perhaps suggests higher germination but lower survival for *Q. ellipsoidalis*. Even though its contribution is low, *Prunus serotina* is also present in both reproduction strata Also of note is the presence of *Fraxinus pennsylvanica* (Green Ash) as a seedling. The high representation of the oaks in the reproduction layers and the fact that oaks are generally long-lived, may indicate that the forest will remain much the same in the future as it is at present, with perhaps a tendency to even greater dominance by *Q. macrocarpa*. Successional change will probably be very slow.

This stand covers an area of at least 8 ha and forms part of an extensive forest complex. The average tree height is between 12 and 14 m and the canopy, although generally continuous, is typical of the more open southern and prairie-edge oak forests with a somewhat open leaf cover and occasional small gaps. In many respects it possesses structural and compositional features characteristic of those of the Southern Deciduous Forest region rather than of the surrounding boreal or mixed forests. This physiognomy is produced by the dominance of the oaks and further enhanced by the presence of *Prunus serotina*, the number of shrubs and herbs of southern distribution, and the paucity of boreal species. The richness of species is also a feature of southern stands; the total

TABLE 1—Quantitative data on the tree composition of *Quercus macrocarpa* – *Quercus ellipsoidalis* forest, Oak Point, Wildland Township, Rainy River District, Ontario

Tree species	Seedling relative frequency	Sapling relative density	Tree relative frequency	Tree relative density	Tree relative dominance	Tree importance value
Quercus macrocarpa	17	67	37	51	36	124
Quercus ellipsoidalis	55	2	26	21	29	76
Betula papyrifera	—	9	14	12	13	39
Populus tremuloides	17	15	14	11	14	39
Pinus strobus	—	—	4	2	7	12
Prunus serotina	11	7	4	2	1	7
Populus balsamifera	—	—	1	1	1	3
Pinus resinosa	—	—	—	—	—	< 1
Pinus banksiana	—	—	—	—	—	< 1
Ulmus americana	—	—	—	—	—	< 1
Fraxinus pennsylvanica	< 1	—	—	—	—	—
	100	100	100	100	100	300

species list of 97 vascular plants is quite noteworthy for such a northern location. Table 2 is a list of the 24 shrubs and 62 herbs found, with species in descending order of frequency.

TABLE 2—Understorey composition of *Quercus macrocarpa Quercus ellipsoidalis* forest, Oak Point, Wildland Township, Rainy River District, Ontario

Species	Frequency
Woody Species	
Corylus cornuta	73
Prunus virginiana	53
Viburnum rafinesquianum	53
Amelanchier sanguinea	47
Cornus racemosa	33
Lonicera dioica	27
Rhus radicans	27
Vaccinium cespitosum	20
Rubus idaeus	13
Rosa acicularis	13
Symphoricarpos albus	13
Crataegus succulenta	10
Viburnum lentago	7
Prunus nigra	7
Acer spicatum	7
Cornus stolonifera	7
Corylus americana	7
Diervilla lonicera	7
Cornus alternifolia	< 1
Lonicera canadensis	< 1
Lonicera hirsuta	< 1
Viburnum trilobum	< 1
Salix humilis	< 1
Vitis riparia	< 1
Herbs	
Maianthemum canadense	100
Carex pensylvanica	93
Oryzopsis asperifolia	93
Osmorhiza claytoni	80
Streptopus roseus	80
Uvularia sessilifolia	73
Uvularia grandiflora	67
Sanicula marilandica	67
Galium triflorum	67
Aster ciliolatus	60
Fragaria virginiana	47
Rubus pubescens	40
Galium boreale	40
Aralia nudicaulis	33
Thalictrum dioicum	33
Pyrola elliptica	33
Viola pensylvanica	27
Lathyrus ochroleucus	20
Pyrola asarifolia	20
Pteridium aquilinum	13
Phryma leptostachya	13
Osmorhiza longistylis	13
Luzula acuminata	13

TABLE 2—*(concluded)*

Species	Frequency
Herbs *(concluded)*	
Actaea rubra	13
Anemone quinquefolia	13
Apocynum androsaemifolium	7
Circaea quadrisulcata	7
Clintonia borealis	7
Lysimachia ciliata	7
Polygonatum pubescens	7
Taraxacum officinale	7
Smilax lasioneura	7
Bromus ciliatus	7
Zizea aurea	7
Viola sororia	7
Agastache foeniculum	7
Heracleum maximum	7
Lactuca biennis	< 1
Hieracium canadense	< 1
Petasites palmatus	< 1
Schizachne purpurascens	< 1
Cypripedium calceolus	< 1
Geum aleppicum	< 1
Thalictrum polygamum	< 1
Elymus diversiglumis	< 1
Vicia americana	< 1
Pyrola secunda	< 1
Anemone virginiana	< 1
Lathyrus venosus	< 1
Smilacina racemosa	< 1
Prenanthes alba	< 1
Lilium philadelphicum	< 1
Cornus canadensis	< 1
Carex pedunculata	< 1
Carex deweyana	< 1
Botrychium virginianum	< 1
Aster umbellatus	< 1
Aster macrophyllus	< 1
Aster lateriflorus	< 1
Aquilegia canadensis	< 1
Agrimonia gryposepala	< 1
Mitella nuda	< 1

The complex structure of this stand can be summarized in terms of the dominant species comprising each layer. Species components can be divided into layers according to height and life form with species contributing most to biomass arranged in order of decreasing contribution within each layer.

1) Tree layer — continuous, to 14 m; dominated by *Quercus macrocarpa – Quercus ellipsoidalis – Betula papyrifera – Populus tremuloides.*
2) Sapling Reproduction layer — ± continuous, to 6 m; *Quercus macrocarpa.*
3) Tall Shrub layer — continuous to 3 m; *Corylus cornuta – Prunus virginiana – Cornus racemosa – Amelanchier sanguinea.*

4) Tall Herb layer — ± continuous but sparse to 30 cm; *Uvularia grandiflora* – *Streptopus roseus*.
5) Lower Herb layer — ± continuous to 15 cm; *Carex pensylvanica* – *Aster ciliolatus* (rosettes).
6) Cryptogam layer — discontinuous and sparse.

Order of Understorey Dominance — *Corylus cornuta* – *Prunus virginiana* – *Cornus racemosa* – *Amelanchier sanguinea* – *Viburnum rafinesquianum*.

A conspicuous feature is the extremely heavy, continuous, tall shrub layer. Although this is not an unusual stratum to be found in the boreal forest region, the density, the number of species as well as the actual species involved, are certainly uncommon. A total of 15 tall shrub species, many of southern distribution combine to form this heavy layer (Table 2). The complexity of this stratum at this latitude is quite astounding and its richness is probably related to the fairly strong penetration of light to lower levels of the forest which is permitted by the somewhat open canopy.

None of the members of the herb stratum contribute to biomass in the understorey to the extent that any of the shrub elements do. Although it is not as dense, the herbaceous component is also rich in species and structural variation as indicated in Table 2. In the tall herb layer of medium height *Uvularia grandiflora* (Large-flowered Bellwort) and *Steptopus roseus* (Rose Mandarin) are important contributors which have relatively high frequency values. In the low herb layer *Carex pensylvanica* (Pennsylvania Sedge) and *Aster ciliolatus* (Marginal-hairy Aster) are significant contributors to biomass and have higher frequency. Several other species including *Maianthemum canadense* (Wild Lily-of-the-valley), *Oryzopsis asperifolia* (Mountain-rice Grass), *Osmorhiza claytoni* (Sweet Cicely), *Uvularia sessilifolia* (Wild Oats), *Sanicula marilandica* (Black Snakeroot), and *Galium triflorum* (Sweet-scented Bedstraw), are ubiquitous and attain higher frequency values. A number of herbs are interesting because of their more western geographical affinities and seldom occur farther eastward in forests in Ontario. These are *Lathyrus ochroleucus* (Pale Vetchling), *Smilax lasioneura* (Hairy Carrion-flower), *Agastache foeniculum* (Blue Giant Hyssop), *Elymus diversiglumis* (Interrupted Wild Rye), *Vicia americana* (American Vetch), and *Lathyrus venosus* (Veiny Vetchling).

The environmental features that have permitted this rich structural and floristic complexity were also examined. Moisture availability was assessed in the field as dry-mesic. Vigorous drainage on a fine sand strongly affects this situation. The soil is not markedly acid with a field pH of 6.0. Thus warmer than normal microclimatic influences coupled with well drained sandy soil of moderate acidity are important features producing the growth conditions responsible for this community.

Phytogeographical Considerations

Most notable of the range extensions is that of *Quercus ellipsoidalis* which can now be considered as forming a part of the tree flora of Canada. It is a northern midwestern species which is thought to have a distribution pattern that centers on the Driftless Area of Wisconsin. It is essentially a tree of the forest-prairie edge in midwestern North America. It grows in dry, sandy habitats, especially sandplains and sandstone hills in this region and only attains extensive pure populations on such sites (Curtis 1959). The disjunct occurrence at the extreme northwestern edge of its range in northwestern Ontario provides reason for speculation on the ecological basis for this distribution pattern.

There are complex problems associated with the migration of oak species at any period in history, but especially during relatively brief episodes of climatic change in postglacial times. The heavy acorns are an effective agent for establishment once they fall into a favorable environment but certainly present difficulties for long-distance dispersal. Squirrels move only restricted distances from tree cover into the open and thus the spread of these trees into open ground would be slow and the movement of such shade-tolerant trees through established forests would be very slow or impossible.

It would seem that a logical explanation for the existence of this tree in northwestern Ontario is slow migration into the region during the postglacial xerothermic as a tree element associated with prairie, and then survival on only very specialized sites afforded in warmer elevated lakeshore fringes on well drained sandy substrates, as a more boreal forest cover became established during climatic deterioration. A similar scattered distributional pattern in adjacent Minnesota (Little 1971) coupled with survival only on extremely favorable environmental sites would seem to lend support to the relict status of the species.

The presence of this oak is strongly influenced by fire (Curtis 1959) and the maintenance of the species in this area will probably decrease in the absence of this agent.

Supporting references or maps relating to its distribution elsewhere in areas adjacent to Canada include Lakela (1965) and Little (1971). Such supporting references or maps for other species in or adjacent to Canada discussed here, when available, are included in parentheses following the range extensions indicated. Specimens supporting these records are deposited in the research herbarium of the senior author and in TRTE.

The discovery of *Prunus serotina* in the Rainy River region represents an extension of known range of 282 km northwestward from the nearest sites in Minnesota. This is a significant discovery for this region (Fox and Soper 1953; Hosie 1969; Little 1971). The presence of this tree in this region is more problematical to account for than Hill's Oak because the disjunction involved is much more extensive. Black Cherry is a widely distributed tree essentially of the entire Deciduous Forest but it is restricted in its occurrence in the extreme northwestern sections, being found from central Minnesota and throughout Wisconsin and thence southward to Texas. In the Midwest it is an important tree particularly as a sapling and smaller tree associated with dry forests (Curtis 1959). The very limited occurrence of this tree near Lake of the Woods would suggest that it is a relict of former more extensive populations there which may have been associated with deciduous forests of a more southern or drier character which were more widespread in the postglacial Hypsothermal. The considerable disjunction is not easily accounted for because it would seem that suitable habitats should be available in the intervening areas; however, the fact that these disjunct species are growing together in the same site with similar ecological characteristics may lend extra support to the idea that they moved in together and have been left behind together when climatic features changed.

Elymus diversiglumis (Interrupted Wild Rye) is restricted in its distribution in Ontario to the extreme northwestern sector of the province although it is found farther west in Canada. This record for Oak Point is the second report for Ontario (Bowden 1964).

A number of other plants are common elements in the Bur Oak – Hill's Oak forest of Oak Point and have been reported elsewhere in Ontario but have either not been presented in published accounts for northwestern Ontario or are of such sporadic occurrence there, that it is worthwhile to draw attention to their existence. Such plants have notable ranges in Ontario because they are found throughout southern sectors sometimes as far north as the southeastern Lake Superior region, are absent north of the lake, but then are established in northwestern sectors, west and southwest of Lake Superior.

One group is restricted to southern Ontario and then is found west of Lake Superior. An extensive gap up to 965 km in extent is found in the distribution of these species in the province. It includes Panicle Dogwood (*Cornus racemosa*) (Soper and Heimburger 1961), American Hazel (*Corylus americana*) (Soper and Heimburger 1961), Hairy Carrion-flower (*Smilax lasioneura*), Wild-oats (*Uvularia sessilifolia*) (Soper 1952; Wilbur 1963), and Golden Alexanders (*Zizia aurea*).

The other group is made up of species that are found in southern Ontario but pass farther northward to the areas due east of Lake Superior but then are not present north of the lake but are west of it. These have a gap in their distributional patterns, but not as extensive as those of the first group. A large number of plants of the Oak Point forest have this type of pattern. Agrimony (*Agrimonia gryposepala*) (Rousseau 1974), Enchanter's Nightshade (*Circaea quadrisulcata*) (Haber 1967), Pagoda Dogwood (*Cornus alternifolia*) (Hosie 1969), Green Ash (*Fraxinus pennsylvanica*) (Hosie 1969; Little 1971), Lopseed (*Phryma leptostachya*), Solomon's Seal (*Polygonatum pubescens*) (Ownbey 1944), Canada Plum (*Prunus nigra*) (Hosie 1969), Bur Oak (*Quercus macrocarpa*) (Hosie 1969; Little 1971), Large-flowered Bellwort (*Uvularia grandiflora*) (Soper 1952; Wilbur 1963), Wild Raisin (*Viburnum lentago*) (Soper and Heimburger 1961), and River-bank Grape (*Vitis riparia*), form the extensive number of species included in this group.

This site thus provides conditions of uncommon ecological occurrence, which enables a unique group of species to persist northward and interesting phytogeographical patterns have resulted from this.

Botanists have long regarded southern Ontario as a ies; however, it is hoped that this report on findings in northwestern Ontario will stimulate interest in the diverse flora and vegetation in this often ignored area.

Acknowledgments

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Intergradation of Eastern American Common Eiders

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Bill measurements were taken of adult females of three subspecies of North American Common Eiders: *Somateria mollissima dresseri, S. m. borealis,* and *S. m. sedentaria,* and also *borealis-dresseri* intergrades, as an aid in recognizing these races. Live birds and fresh specimens were primarily from Labrador, Newfoundland, and Maine, and museum skins were from various parts of their ranges. Of four bill measurements used, the culmen midline length commonly given in avian literature was the least helpful. Total bill length and/or the distance from the nostril to the posterior extension of the frontal lobe permitted separation ($P < 0.05$) of most individuals of the various subspecies and population groups, including intergrades. Facial feather patterns and plumage coloration varied too much to be reliable as criteria for racial identification. Intergradation between *borealis* and *dresseri* occurs regularly on the central Labrador coast, and *borealis* probably also intergrades with other subspecies where their breeding ranges overlap.

Key Words: Common Eider, *Somateria mollissima,* eastern America, subspecies, intergradation, bill-length, racial studies.

Palmer (1976) recognized five subspecies of *Somateria mollissima* in North America and presented general information on overlaps in their breeding ranges. Morphological clines and subspecies intergradation are to be expected in a wide-ranging species such as the Common Eider, but little specific information is in the literature. *Borealis-dresseri* intergradation on the Labrador coast has been assumed since Beetz (1916) described an "intermediate" eider from the Gulf of St. Lawrence. Palmer's (1976, pp. 33–34) account of intergradation in the Cartwright-Makkovik region was based on preliminary data from the present study.

The breeding biology and winter population of *S. m. dresseri* have been studied in Maine, where this subspecies has increased markedly in recent years (Mendall 1968, 1976). Maine is also included in the winter range of *S. m. borealis*. During sampling to estimate the proportion of each subspecies in the winter population, we obtained a number of specimens that appeared to represent *borealis-dresseri* intergrades.

Hamilton Inlet on the south-central Labrador coast has long been considered (Bent 1925; Todd 1963; Godfrey 1966) as an approximate boundary between the breeding areas of *borealis* and *dresseri.* In 1972 our studies there consisted of an aerial survey along the entire coast, brief ground checks of nesting islands, and specimen collecting by William Snow, United States Fish and Wildlife Service. More detailed investigations were made in Labrador by Snow and me during July of 1974 and 1975. We covered some 350 km of the coast, with most intensive ground studies in Groswater Bay (54° 15′N), and in Table Bay (53° 40′N).

This paper presents data on bill measurements of eastern American Common Eiders, to supplement racial identification by other, more subjective characteristics, and discusses intergradation between the subspecies.

I have given primary attention to *S. m. borealis* and *S. m. dresseri.* The breeding range of the former is also in proximity to, or in contact with, two other subspecies, *S. m. sedentaria* in Hudson Bay and *S. m. islandica* in Greenland. Schiøler (1926) and Palmer (1976) concluded that *islandica* is the breeding eider of southwestern Greenland, with *borealis* occurring on the northwest coast. The characteristics of the breeding birds within an extensive zone of western Greenland are unknown.

Methods

In Maine, female eiders were captured either with long-handled nets as they flushed from nests in light cover, or on their nests using automatic drop-door traps modified (Korschgen 1976, p. 13) from the type designed by Weller (1957). In Labrador, long-handled nets were of little use, since most birds nested either on open tundra where they could not be closely approached, or in thickets too dense to use nets.

Most breeding females caught were banded and released after tentative subspecific identification, plumage examination, and weighing; bill measurements were taken of most birds. In addition to nesting females, we examined embryos and newly hatched ducklings from 159 nests. A representative series of both females and embryos was preserved for the University of Maine museum. The frontal lobes of the bill in *borealis* are noticeably narrower, shorter, and much more acutely pointed than in *dresseri*; the

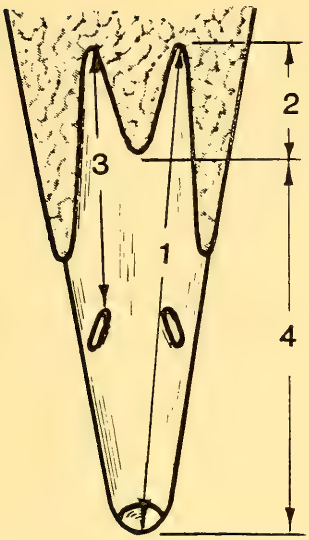

FIGURE 1. Points of measurement of Common Eider bills.

broad, rounded lobes of the latter are usually readily apparent. Frontal lobes of *sedentaria* resemble those of *dresseri* but are smaller. Plumage coloration (pale gray or gray-buff) is also helpful in identifying *sedentaria*, but this character by itself is not always reliable (see Results). For subspecific bill descriptions, see especially Snyder (1941), Todd (1963), Godfrey (1966), and Palmer (1976). I identified intergrades as birds wherein the frontal lobes were either narrow (more so than in *dresseri* or *sedentaria*) and semi-rounded (or nearly square), or broad but conspicuously short.

The Maine and Labrador data from live eiders served as the basis for comparison with preserved birds from other sources: University of Maine, Bowdoin College, Museum of Comparative Zoology, Carnegie Museum, United States National Museum, and Royal Ontario Museum. In addition, fresh specimens from southern Labrador and Newfoundland and preserved skins in the National Museum of Canada were examined and measured by Douglas Gillespie, former biologist of the Canadian Wildlife Service, who kindly sent me his records.

Four bill measurements taken by D. Gillespie (personal communication) were adapted for my studies (Figure 1) and defined as follows:

1) Total length: from tip of bill to posterior end of the frontal lobe,
2) Frontal extension: from anterior end of feathering on top of middle of bill to posterior end of frontal lobe,
3) Nostril–extension: from posterior end of nasal opening to posterior end of frontal lobe,
4) Culmen midline (= "exposed culmen" of standard measurements): from anterior end of feathering on top of middle of bill to the tip of the bill.

Most authors have given only the midline length of the culmen in describing eider bills, although a few publications have included frontal extension or total length; apparently none have used nostril–extension length. To standardize the data, we took all measurements used in this paper, other than culmen midline, on the right side of the bird. I excluded birds with damaged or shriveled bills. My identifications of other museum specimens agreed with those originally recorded on museum tags, with the exception of six individuals which I considered to be intergrades (see Results).

Only adult females are included in the tabulations of bill measurements. The numbers of known immature and subadult females and of males from known breeding localities were too few for comparable statistical treatment. Moreover, males offer fewer problems in identification on the basis of shape of the bill process alone. Other racial differences, including plumage, as described in the literature, were recorded for most specimens that I examined.

It is not certain that all museum specimens of *borealis* from Baffin and Ellesmere islands and northern Labrador represented actual nesting birds, but they were adult females obtained within the known breeding range. All of the eiders from central and southern Labrador, Newfoundland, and Maine were known nesters.

TABLE 1—Means, standard deviations, and ranges of four bill measurements of summer-collected female Common Eiders (N = 220)

Groups and regions of collection	N	Bill measurements (mm) Culmen midline $\bar{x} \pm$ SD (range)	Frontal extension $\bar{x} \pm$ SD (range)	Nostril-extension $\bar{x} \pm$ SD (range)	Total length $\bar{x} \pm$ SD (range)
borealis, except Greenland	65	46.84 ± 2.57 (41.0–52.5)	17.06 ± 1.81 (13.5–21.0)	28.45 ± 2.05 (22.0–32.5)	63.22 ± 2.30 (59.5–68.0)
intergrade, central Labrador	32	47.90 ± 3.38 (41.0–54.5)	17.94 ± 1.90 (15.0–22.0)	30.89 ± 2.12 (27.5–35.0)	65.77 ± 1.82 (62.0–69.0)
dresseri, central Labrador	41	50.85 ± 3.03 (44.0–57.0)	21.20 ± 2.04 (17.5–27.0)	36.06 ± 1.83 (32.0–40.0)	71.51 ± 1.99 (68.0–76.0)
dresseri, south Labrador and Newfoundland	26	51.52 ± 3.40 (46.0–58.0)	22.35 ± 2.34 (18.0–26.0)	36.62 ± 2.19 (32.0–40.0)	72.96 ± 2.40 (69.5–79.0)
dresseri, Maine	34	51.79 ± 3.23 (46.0–58.0)	22.72 ± 1.46 (19.5–26.0)	37.71 ± 1.90 (33.0–41.5)	74.34 ± 2.61 (69.5–80.0)
sedentaria, Hudson Bay	22	51.91 ± 1.94 (47.0–54.5)	20.07 ± 1.96 (17.0–23.0)	34.80 ± 1.93 (31.0–39.0)	70.48 ± 2.03 (67.5–74.0)
Analysis of variance[1]		F = 23.8 ($P < .05$)	F = 62.8 ($P < .05$)	F = 150.4 ($P < .05$)	F = 168.9 ($P < .05$)

[1]Degrees of freedom are 5 and 214 in all cases.

Bill measurements were recorded to the nearest 0.5 mm. To test the validity of combining data from fresh material and museum skins, I re-measured 43 preserved specimens (21 *dresseri*, 10 *borealis*, 12 intergrades) that I had measured when fresh, 3–11 yr previously. Little bill shrinkage had occurred; mean differences ranged from less than 0.5 mm in the two shorter measurements of *borealis* to less than 1 mm in total bill length of *dresseri*. Since shrinkage appeared to be no greater than human variation in taking the measurements, I combined data from museum and fresh specimens in a few of my tabulations.

Available data were grouped by regions of collection and by season. Subspecific identification was by bill process shape only. Statistical treatment of the data groups was by one-way analysis of variance ($P < 0.05$) and multiple-range comparison of means by the Student-Newman-Keuls procedure (Zar 1974). This compared homogenous subsets of the data groups, no pair of which had means that differed by more than the shortest significant range for a subset of that size.

Results

Bill Measurements

Initial comparisons included all samples in Table 1, and also summer specimens from Greenland and winter specimens from eastern North America. Testing, by analysis of variance and multiple-range tests,[1] showed extensive overlaps in culmen midline measurements of most groups, but suggested that other bill measurements permitted better separation. Since the winter samples could not be related to specific breeding areas, they were excluded from subsequent comparisons. Summer-collected Greenland birds, classified as *borealis*, were excluded because of the possibility of *borealis-islandica* intergrades. The summer groupings are shown in Table 1.

The analysis of variance and multiple-range tests of the means of these groups of eiders (Table 1) emphasized the value of total length and nostril–extension measurements. By both these criteria, all *borealis* were distinct (Table 2) from any others examined. Likewise, Labrador intergrades formed a discrete group. Labrador and Newfoundland *dresseri* overlapped to a limited extent in nostril–extension; but *dresseri* as a subspecies separated from all other groups. A slight overlap in total bill length occurred between *sedentaria* and central Labrador *dresseri*. Maine *dresseri* were distinct from any other group, and had bills significantly larger in two of the three best measurements than others of this race or of *sedentaria*; by contrast, central Labrador *dresseri* had bills significantly smaller in two of the three best measurements than those of the other geographical groups of this subspecies (Table 2).

In addition to the measurements just discussed, it may be seen from Table 2 that the groups also separated well for the length of the frontal extension; however, this difference is not as strong (see F ratios of Table 1) as those of nostril–extension and/or total

[1]The statistical data from that preliminary analysis are not presented here, but are available from the Maine Cooperative Wildlife Research Unit.

TABLE 2—Multiple range test for means of four bill measurements, in millimetres, of Common Eiders (N = 220). (Solid lines under group means indicate homogenous subsets, no pair of which have means that differ by more than the shortest significant (95%) range for a subset of that size)

Culmen midline						
Group	*borealis*	intergrade	*dresseri*[1]	*dresseri*[2]	*dresseri*[3]	*sedentaria*
Group mean	46.84	47.89	50.85	51.52	51.79	51.91
Frontal extension						
Group	*borealis*	intergrade	*sedentaria*	*dresseri*[1]	*dresseri*[2]	*dresseri*[3]
Group mean	17.06	17.94	20.07	21.20	22.35	22.72
Nostril extension						
Group	*borealis*	intergrade	*sedentaria*	*dresseri*[1]	*dresseri*[2]	*dresseri*[3]
Group mean	28.45	30.89	34.80	36.06	36.62	37.71
Total length						
Group	*borealis*	intergrade	*sedentaria*	*dresseri*[1]	*dresseri*[2]	*dresseri*[3]
Group mean	63.22	65.77	70.48	71.51	72.96	74.34

[1]Central Labrador.
[2]South Labrador; Newfoundland.
[3]Maine.

length. The limited taxonomic value of the culmen midline measurement is evident from Tables 1 and 2.

Phillips (1926, p. 112) stated that *dresseri* could usually be separated from other subspecies as follows: the distance from the posterior end of the nostril to the posterior end of the frontal extension "is as great as or greater than" from the posterior end of the nostril to the tip of the bill. In the present study I used this character only initially. It held fairly well in separating *borealis* from *dresseri* but was too variable when *sedentaria* or intergrades were involved.

Facial Feather Pattern

Several authors, including Snyder (1941), Manning (1952), Griscom and Synder (1955), Todd (1963), and Schiøler (1926) used the position of the nostril relative to the lateral facial feathers as a subspecific criterion. Determinations were usually made from the anterior point of the feathers to a vertical line from the posterior edge of the nostril. I recorded this relationship for most specimens examined (Table 3), including all age and sex classes.

This character was too variable to be of much assistance in classifying Common Eiders, although if the feathers terminate behind the nostril line the bird is unlikely to be *dresseri*.

Plumage Coloration

I recorded plumage coloration of female eiders, primarily by the Villalobos system (Palmer 1962, p. 4), as: *tawny* (including chestnut, rufous, and rusty); *tawny-brown* (including tawny-buff); *brown; gray-brown* (including gray-buff), and *gray*. Plumage coloration varied too much to be very helpful in racial allocation. *Borealis* specimens from Labrador tended strongly toward gray and gray-brown, whereas brown was the predominate body color in Ungava. Most *sedentaria* specimens were noticeably pale gray or

TABLE 3—Relationship of lateral facial feathers to nostril[1] (all sexes and ages combined, N = 344)

		Number of birds			Percent		
Classification	(N)	Ahead	Even	Behind	Ahead	Even	Behind
borealis	122	33	62	27	27.1	50.8	22.1
intergrade	44	19	17	8	43.2	38.6	18.2
dresseri	115	93	21	1	80.9	18.3	0.9
sedentaria	63	8	41	14	12.7	65.1	22.2

[1]Distance is measured from anterior point of facial feathers to vertical line from bottom of upper mandible through posterior edge of nostril. Point of feathers is recorded as ahead of, even with, or behind vertical line.

gray-buff as described by Snyder (1941) and Palmer (1976, p. 32). Several gray *borealis*, live-trapped in Labrador, however, could not be distinguished by color alone from at least five *sedentaria* specimens which lacked the usual paleness in plumage of that race. Variation was also noted frequently in *dresseri*, and intergrades showed no consistency in plumage coloration. The effects of the bird's age, and of plumage wear and fading during summer, add to descriptive problems with female eiders.

Intergradation

Labrador. Beetz (1916) described an "intermediate eider" that was present with *borealis* and *dresseri* along the north shore of the Gulf of St. Lawrence during winter and in migration, and thought that this form might nest there. In an appendix to Beetz' paper, C. W. Townsend suggested that this intermediate eider was the result of *borealis-dresseri* mating, with Labrador as the probable area of origin. This conclusion has been accepted by most subsequent writers, with the Hamilton Inlet area on the south-central Labrador coast considered the location of subspecies overlap. Austin's (1932, p. 49) comment that intermediate forms have been found breeding from southern Baffin Island to the Gulf of St. Lawrence may have been based on summer occurrences of such birds rather than on nesting records.

The presence of intergrades in the breeding season does not, in itself, indicate breeding. Within an eider population, non-breeding individuals may occur throughout the summer range of the race and include immatures, subadults (yearlings or 2-yr birds), non-breeding adults, molting males, and unsuccessful nesting females. During my examination of museum specimens, six eiders labelled *borealis* or *dresseri* differed from most examples of those races, and I considered these as intergrades. They were collected in summer at scattered localities from Ellesmere Island to Labrador, but were not recorded as nesting, and thus are not included in Tables 1 and 2 with the freshly measured nesting intergrades.

Based on known-aged embryos of Maine *dresseri*, the shape of the bill processes is sufficiently developed by the midpoint of incubation to indicate probable subspecies in many cases. Examination of embryos or ducklings from 159 nests, on various islands from Hopedale (55° 30′N) south to St. Peters Bay (52° 05′N), in conjunction with determinations from adults, made it clear that mixed breeding of the two subspecies, and of intergrades, is of most importance in Groswater Bay. But the zone of overlap extends for roughly 160 km north and south of there. Adult females of *borealis*, *dresseri*, and intergrades were taken at each of the study islands in both Groswater and Table bays. In addition, intergrade embryos were obtained at the Bay of Islands near Hopedale on islands where adults were not trapped; also in Partridge Bay about 300 km south (53° 10′N), although *dresseri* embryos predominated there. In St. Peters Bay, all embryos examined appeared to be *dresseri*; also six nesting females obtained there by Douglas Gillespie (personal communication) in 1969 were clearly *dresseri*. Available literature gives no authentic records of breeding *borealis* south of Table Bay, nor any records of adult female *dresseri* north of Makkovik (55° N). On the basis of present evidence, *borealis–dresseri* intergradation occurs only from Partridge Bay north to Hopedale.

Hudson Bay. Both Snyder (1941) and Todd (1963) felt that *sedentaria* was not in contact with *borealis* at any season. An overlap in breeding range around Chesterfield Inlet (63° N), however, was pointed out by Freeman (1970). Thus, intergradation might be expected in the northwest part of Hudson Bay, as implied by Palmer (1976, p. 34). Two breeding females in the University of Maine collection, obtained at the mouth of the McConnell River (61° N), were described by Palmer as being typical *sedentaria* except in body size, which resembled the smaller *borealis*. Two specimens in the Carnegie Museum from the east side of Hudson Bay labelled as *sedentaria* approached minimum bill sizes for this race and had frontal lobes suggestive of Labrador intergrades. One of these birds (#50277) had also proved puzzling to Todd (1963, p. 184), but he classified it as *sedentaria*. Three immature eiders in the Royal Ontario Museum (two males and a female) were collected the same day (11 November 1940) near Cape Fullerton (64° N). Shape of the frontal lobes was unlike that of *borealis* and had only a superficial resemblance to *sedentaria*. Bill measurements of the female, which was light buffy-brown in color, were larger than those of any adult *borealis* in Table 1. One male may have been an atypical *sedentaria*, but I believe the other two birds, and possibly all three, were *borealis–sedentaria* intergrades.

Insofar as is known, *borealis* is not in contact with *sedentaria* in northeastern Hudson Bay. There appears to be a hiatus of some 300 km in the breeding ranges of the two subspecies, from near Cape Smith to Cape Wolstenholme (Palmer 1976, p. 34). Sutton (1932) suggested the possibility of *borealis–dresseri* intergrades at Mansel Island, the latter presumably meaning *sedentaria* which had not then been described as a subspecies. Apparently there is no contact between *borealis* and *v-nigra* on the breeding grounds (Godfrey 1966, p. 77; Bellrose 1976, p. 357; Palmer 1976, p. 40–41).

Greenland. Schiøler (1926) considered the Disko region (70° N) as about the northern known limit of *islandica*, and he believed the southern limit of *borea-*

lis to be near Melville Bay or Cape York (76° N). From there south to Disko Island is a long stretch, some 800 km, where breeding eiders of uncertain classification, and probably including intergrades, occur discontinuously.

Discussion

Based on our findings in south-central Labrador, mixed mating occurs with considerable regularity. On each island in Groswater and Table bays where we trapped nesting females, we found all three forms of eiders—*borealis, dresseri,* and intergrades; however, *dresseri* predominated on most islands, and substantially so in Table Bay.

It is uncertain as to when mixed mating occurs. Beetz (1916) suggested that *dresseri* males from the St. Lawrence River on early molt migration northeastward through the Strait of Belle Isle may be still in breeding condition and mate with *borealis* females in Labrador. This seems unlikely as a regular occurrence, although there is almost a month's difference in breeding chronology. Whether north-bound molting *dresseri* drakes would be in physiological condition for successful mating is unknown.

A large proportion of Common Eiders are already paired when they arrive at the nesting islands, which suggests that pairing occurred on the wintering areas or during migration. In Maine, a minority of birds (a substantial number in some years) are still courting and pairing when nesting by early breeders has commenced. Our banding data suggest that these late pairing individuals are often young adult females; age of the males involved is unknown. On the wintering areas, there is ample opportunity for mixed pairing, as all races except *sedentaria* overlap extensively during winter, especially in the Gulf of St. Lawrence, Newfoundland, and probably Nova Scotia. During winter studies in Maine in 1966–1973, we found, among 1085 eiders of all sexes and ages, only about 4% intergrades and slightly over 2% *borealis.* Among 22 eiders taken (illegally) in late winter and early spring 1976 on the north shore of the Gulf of St. Lawrence, I identified eight (36%) as intergrades. Bill measurements by Pierre Dupuis (personal communication) of 26 eiders confiscated from the same area the following year indicated a comparable situation.

If mixed pairing of races on the wintering grounds occurred regularly, however, we would expect intergradation over an extensive portion of the breeding range. Instead, *dresseri–borealis* intergradation is known in only a limited portion of their breeding ranges. Moreover, nothing in available literature indicates that *borealis* and *sedentaria* are in contact during winter. If intergradation between these subspecies occurs, as seems likely, it would have to be in spring in northwestern Hudson Bay. Thus, I am of the opinion that mixed mating occurs primarily on the breeding grounds.

Although the data in this paper pertain largely to adult females, similar relationships in bill size probably hold for the other sex and age groups, according to preliminary analyses (t-test) by Myrtle Bateman during the initial phase of this study. All sex and age groups of *dresseri* and *borealis* were included, but the samples were smaller than those used in the present paper and were not grouped geographically.

As previously stated, few authors have presented eider bill measurements other than the culmen midline. I have found no studies that used the nostril–extension measure. The length of the frontal extension was given by Snyder (1941) and MacPherson and McLaren (1959). Total length was used by Palmer (1976) and Schiøler (1926). Most published measurements agree well with the present data for *borealis,* except that Schiøler's Greenland birds averaged slightly longer bills than the *borealis* that I measured. Schiøler's measurements approached those he gave for *islandica* which according to Palmer (1976), are larger than *borealis.*

Recognition of eider intergrades requires subjective decisions, as for example whether a given specimen is an intergrade or an atypical *dresseri* or *borealis.* Yet, by considering both shapes and measurements of bill processes, I believe most such instances can be resolved with reasonable accuracy.

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Weather and the Migration of Canada Geese across Southeastern Ontario in Spring 1975

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The migration of Canada Geese, *Branta canadensis interior,* through southeastern Ontario in spring 1975 was studied using radar and visual observations. Most geese probably came from migration stop-over areas in northern New York State. Between 22 April and 14 May at least 190 000 Canada Geese were estimated to have moved through the Ottawa area. Migration directions ranged from 340° to 37° with a mean of 16.8°. Migration ended a few days later than usual, probably as a result of a spell of unfavorable weather. Migration volume was significantly correlated with following wind and with change in temperature. With one exception, all heavy migration occurred under or near the west side of a ridge of high pressure. On one day late in the season heavy migration occurred on the west side of a low-pressure area.

Key Words: Canada Goose, *Branta canadensis interior*, spring migration, weather, Ontario.

Canada Geese migrating across southeastern Ontario in spring belong to the mid-Atlantic wintering population which spends the winter along the eastern seaboard of the United States and breeds in northern Quebec. That population consists largely of *Branta canadensis interior*, and totals about 650 000 birds after the hunting season. In winter, about 540 000 of those geese are concentrated in Delaware and Maryland, almost due south of Ottawa (Figure 1). The principal breeding grounds lie in the tundra of the Ungava Peninsula with fewer geese nesting in the boreal forest south to the 50th parallel (Bellrose 1978).

Equipment, designed by the National Research Council of Canada, to detect automatically flocks of migrating birds can be used to provide air traffic controllers with information to prevent bird/aircraft collisions (Hunt 1977). During operational tests of that equipment at Ottawa International Airport in spring 1975, films of the radar display showed several migratory flights of Canada Geese. At the request of the Ministry of Transport, the Canadian Wildlife Service (M. C. Gauthier et al., unpublished report) assessed the hazard to flight safety posed by those migrating goose flocks.

This paper presents some information on the migration stop-over areas, chronology, numbers, and directions of the Canada Geese that migrated across the Ottawa area in spring 1975, and examines correlations with weather conditions during the migration period.

Methods and Materials

Visual Observations

From 18 April to 18 May 1975, biologists, bird watchers, and Air Traffic Control personnel at Ottawa International Airport contributed a total of 66 records pertaining to at least 110 flocks of migrating geese and 10 records of resting goose flocks at or near Ottawa, Ontario. All records are listed by Gauthier et al. (unpublished report).

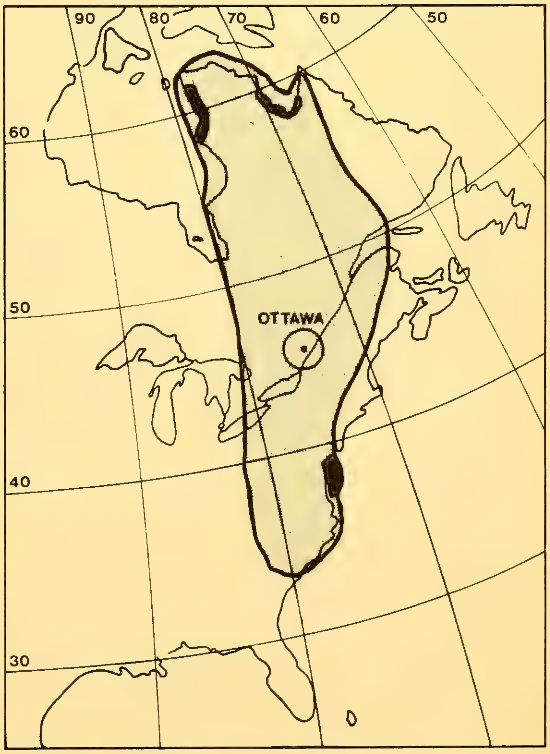

FIGURE 1. Range of the mid-Atlantic population of Canada Geese. Solid black — main wintering area and nesting areas (after Bellrose 1978). Circle — area covered by the Ottawa radar display.

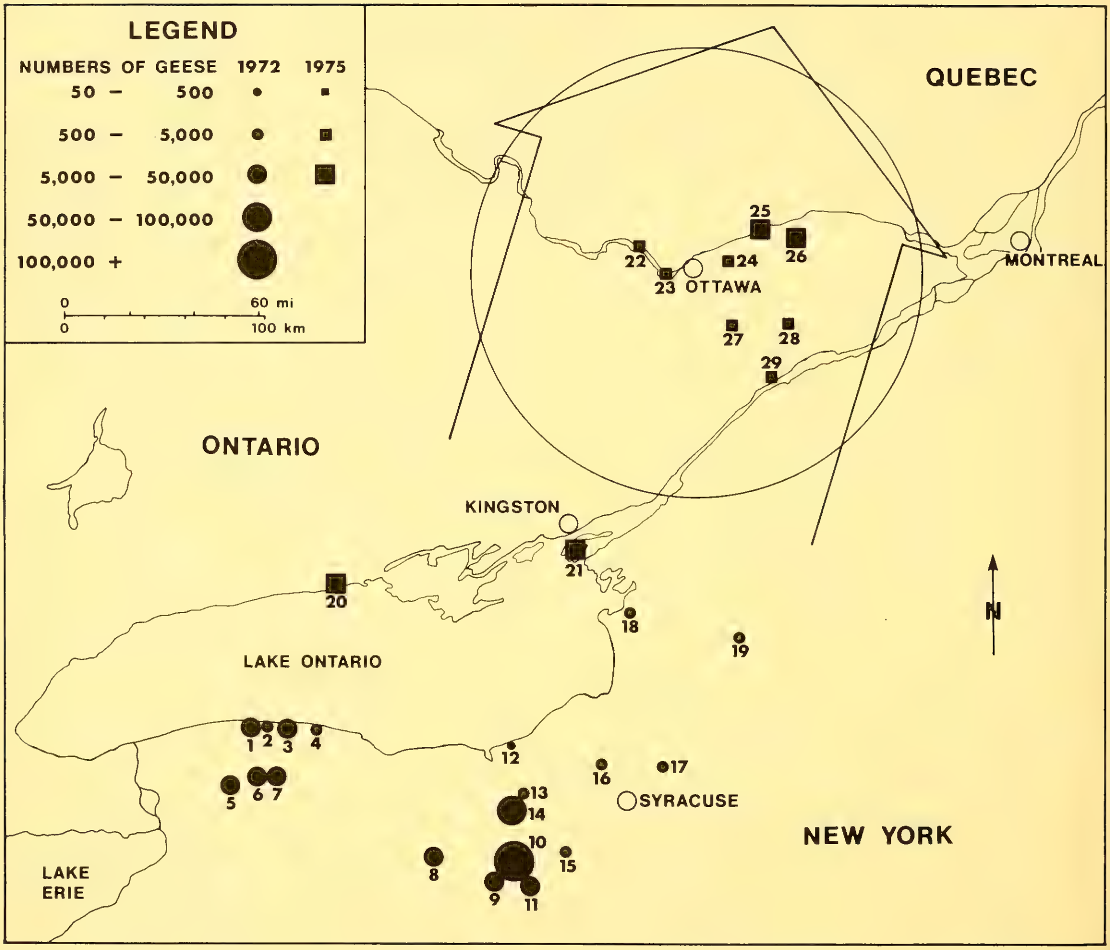

FIGURE 2. Migration stop-over areas of Canada Geese in southeastern Ontario in 1975 (squares) and in north-central New York in 1972 (solid dots), the area covered by the Ottawa radar display in 1975 (circle), and the general direction of "goose echoes" in 1975 (arrow). Numbers identify the locations listed in Table 1.

Radar Observations

Time-lapse 16-mm films were taken of the master display of the 23-cm AASR-1 surveillance radar at Ottawa International Airport in spring 1975. From 14 to 25 April, radar films were taken during only part of the day. Beginning at 19:00 on 25 April and until 13 June, there was 24-h per day film coverage. The range of the radar display was set at 111 km (60 n mi; Figures 1, 2) and the antenna rotated at 6 rpm. Every second radar sweep was recorded on one frame of film. Solman (1969) outlined the camera set-up and Canada Department of Transport (1967) described the AASR-1 radar.

Migrating flocks of geese produce on the screen of an AASR-1 radar relatively large, non-fluctuating echoes moving on a fairly straight course and at a steady speed (Blokpoel 1974). The Ottawa radar films showed many echoes of this kind mostly moving across the screen on a broad front in northerly directions. All such echoes moving in directions between northwest and northeast were considered to be "goose echoes." Heavy movements of "goose echoes" on the Ottawa radar films generally occurred on days and at times when large numbers of migrating Canada Geese were observed visually. Migrating Canada Geese were observed between 22 April and 14 May, and no other geese were observed during that period. No other bird migrates through the Ottawa area during that period in flocks large enough to produce "goose echoes." Hence, we conclude that all or nearly all of the "goose

echoes" on the Ottawa radar films were caused by migrating flocks of Canada Geese. We assume that all or almost all "goose echoes" represented only single flocks of geese. An echo caused by two or more goose flocks is likely to change in size and shape when travelling across the display because the distances between the flocks are likely to change during the flight, but we rarely observed fusion or fission of "goose echoes."

Numbers of "goose echoes" were determined by running the radar film through a Vanguard Film Analyzer and counting the echoes per hour that crossed an imaginary line 30 n mi (54 km) to the south of Ottawa and perpendicular to the average direction of the echoes. Directions of the "goose echoes" were determined by manually tracing the paths of representative "goose echoes" on a sheet of mylar placed over the ground-glass projection screen of the film analyzer.

Weather Data

Weather data included (1) surface and 850-mB maps prepared for 07:00 and 19:00, (2) the standard hourly observations at Ottawa and Syracuse, New York, and (3) upper air winds for Albany, New York, Maniwaki and Montreal, Quebec, for 07:00. In this report, the Ottawa area is the area covered by the radar display (Figure 2). All times are Eastern Standard Time and directions are in degrees from True North.

Results and Discussion

Migration Stop-over Areas

In spring 1975, several stop-over areas near Ottawa were used by Canada Geese (Table 1, Figure 2). The largest concentrations of geese were seen near Plantagenet (approximately 15 000), on the Ottawa River near Thurso (more than 10 000), and near Carlsbad Springs (5000–6000). Farther south in Ontario, 10 000–15 000 resting Canada Geese were reported at Wolfe Island and 10 000–20 000 geese near Colborne.

Counts for 1975 from New York State were not available, but air survey data from 12 and 14 April 1972 give an idea of the usual distribution of geese in north-central New York (Figure 2; S. Browne, personal communication). Largest concentrations occurred near Cayuga Lake. The estimate of nearly 350 000 geese observed during the 1972 survey was undoubtedly low because the survey did not cover the entire area, and because some geese may have left while others had not yet arrived. Evidently northern New York is of major importance as a stop-over area for geese of the mid-Atlantic population, while the Ottawa area is of only minor importance.

Chronology and Time of Day

The visual observations in 1975 indicated that virtually all Canada Goose migration into or across the Ottawa area occurred from 22 April to 14 May. The main migration period was from 23 April to 11 May, the first and last days with considerable migration. The radar films confirmed this, although radar data were incomplete until the evening of 25 April.

Peak numbers of Canada Geese in New York State usually occur in the first two weeks of April. In 1975 the majority of the Canada Geese remained at the staging grounds longer than usual, but most left before 1 May and the last large flights occurred on 10 May (S. Browne, personal communication).

In the Kingston area (Figure 2), the flights of the geese reach their peak at the end of April and beginning of May and ". . . for several days the flocks pass

TABLE 1—Numbers of Canada Geese at migration stop-over areas (*a*) from an aerial survey of northern New York State on 12 and 14 April 1972 — circles in Figure 2 (S. Browne, personal communication) and (*b*) reported for southeastern Ontario between 10 April and 9 May 1975 — squares in Figure 2. WMA — Wildlife Management Area, NWR — National Wildlife Refuge

Number on Figure 2	Location	Numbers of Canada Geese
(*a*) 1	Thirty Mile Point	23 720
2	Johnson Creek	2 000
3	Oak Orchard Creek	7 405
4	Sandy Creek	1 820
5	Tonawanda WMA	35 100
6	Oak Orchard WMA	32 900
7	Iroquois NWR	22 600
8	Honeoye Lake	6 206
9	Seneca Lake	5 595
10	Cayuga Lake (N. of Shelldrake Pt.)	109 595
11	Cayuga Lake (S. of Shelldrake Pt.)	25 600
12	Little Sodus Creek	55
13	Howland Island WMA	2 400
14	Montezuma NWR	61 200
15	Owasco Lake	1 700
16	Three Rivers WMA	1 300
17	Oneida Lake	4 335
18	Crystal Lake	1 100
19	Lowville-Grenfield	4 200
(*b*) 20	Lakeport (near Colborne)	10 000–20 000
21	Wolfe Island	10 000–15 000
22	Luskville	"great numbers"
23	Lac Deschênes	"hundreds"
24	Carlsbad Springs	5000–6000
25	Thurso	> 10 000
26	Plantagenet	15 000
27	Vernon	2000–4000
28	Finch	"thousands"
29	Morrisburg	1 800

steadily northward. By May 10 most have gone" (Quilliam 1973). Records of bird watchers in the Ottawa area showed that in 1976 good numbers of geese were present by the middle of April with large flights occurring at the end of April and the first week of May. In 1977 most migration again took place in the last week of April and first week of May. These two weeks form the usual migration period for the Ottawa area (H. A. McLeod, personal communication). In 1975, the year of our study, goose migration ended later than usual in that many geese migrated on 8–11 May (Goodwin 1975).

Migration was usually heaviest in the morning: 2451 (88%) of the 2784 "goose echoes" counted in the period with complete radar data (26 April–14 May) occurred from 04:00 to 14:00 with peak numbers between 08:00 and 09:00. Relatively few echoes were seen during the rest of the day: 14:00 to 21:00 — 156 echoes (6%), and 21:00 to 04:00 — 177 echoes (6%). Myres and Cannings (1971) also reported that the spring migration of *Branta canadensis parvipes* across the international border into interior British Columbia was diurnal, while F. C. Bellrose (unpublished report) stated that in spring about half the Canada Goose migration occurs at night and half during the day; however, he also mentioned that diurnal movements of geese are "especially prevalent when skies are overcast at night or when winds, temperature or both have not been conducive to northward migration." Sizeable numbers of "goose echoes" occurred on only two nights (28 April and 10 May), both of which had light following winds. On 28 April there was heavy cloud cover whereas on 10 May the sky was clear. During the main migration period (23 April–11 May) there was only one other night with favorable winds: on 1 May winds were light and following but there was light rain. Hence, our results are generally consistent with Bellrose's statements.

Volume of Migration

We counted a total of 2906 "goose echoes" on the radar films covering the period 22 April to 14 May. Daily totals in the period with complete radar coverage (26 April–14 May) ranged from 0 to 350 (mean = 146.2, SD = 123.5, N = 19). The daily totals of echoes fluctuated but there was no obvious pattern. Three of the 4 d with largest movements were consecutive.

Flock sizes for 88 migrating flocks of Canada Geese were provided by observers. They ranged from 6 to 300 birds (mean = 65.7; SD = 51.0). If each "goose echo" represented one flock and the mean flock size was 65.7, the 2906 "goose echoes" represented 190 924 ± 31 598 Canada Geese migrating through the Ottawa area in spring 1975. We calculated the confidence interval using the formula Var T = A^2 Var $\bar{x}$, where T is the estimated total, A is the number of "goose echoes" and $\bar{x}$ is the mean flock size (Cochran 1953). The mean flock size may be biased if small flocks were missed more often than large ones, or if high-flying flocks differed in mean size from those within visual range. We have no data to estimate the extent of such biases.

The estimated 190 000 geese represent almost 30% of the mid-Atlantic population (Bellrose 1978). This is a minimum estimate of the number of Canada Geese that crossed the Ottawa area in spring 1975 because the radar would have missed flocks flying below its horizon and because radar data were incomplete during 22–25 April.

Directions of Migration

Paths of representative samples of "goose echoes" were traced during hours of maximum migration for 29 April, 1, 5, 8, 9, and 11 May. Directions of individual "goose echo" tracks ranged from 340° to 37°. The mean directions of the six samples ranged from 11.0° to 21.4° with a weighted average of 16.8° (total number of echoes traced = 71).

Based on the observed mean direction of the "goose echoes," the periods during which they were recorded on the radar films, the usual time of morning departure of migrating Canada Geese (1 h before to 2 h after sunrise; Bellrose, unpublished report), and their usual ground speed (about 80 km/h; Bellrose 1978), we conclude that most geese flying across the Ottawa area came from migration stop-over areas in northern New York State and along the northeast shore of Lake Ontario (Figure 2). If we assume no change in directions, the flight paths of most of the Canada Geese migrating across the Ottawa area would take them to the shores of Ungava Bay. That area is included in the known breeding range of the mid-Atlantic population (Figure 1).

Weather Variables and Migration Volume

Take-off weather.

We concluded above that most of the Canada Geese migrating across the Ottawa area had probably departed from migration stop-over areas in northern New York State (Figure 2). Syracuse, New York, is a location in that area for which complete weather records were available. Assuming that the geese departed in largest numbers in the early morning, we looked for correlations between weather variables measured at Syracuse at 04:00 and the numbers of geese that apparently departed from the area (i.e., the number of "goose echoes" recorded at Ottawa during 07:00–14:00) for each day during 26 April–11 May. We considered the following variables: temperature relative to normal, change in temperature from that on previous day, relative humidity, change in relative

humidity from that on previous day, cloud cover, change in cloud cover from that on previous day, speed of surface wind (regardless of direction), and expected ground speed in the preferred direction of the geese. Expected ground speed takes into account both the speed and the direction of the wind (cf., Alerstam 1976). We calculated the expected ground speed using the surface wind, a preferred direction of 16.8° (the mean direction of the "goose echoes"), and an air speed of 56 km/h (the air speed for Snow Geese, *Chen caerulescens caerulescens*) (Blokpoel 1974). Only 'change in temperature from that on previous day' was significantly correlated with migration volume ($r_s = 0.628$, $P < 0.01$, N = 16, Spearman's rank correlation test; Siegel 1956). Precipitation and visibility were not considered because the Spearman's rank correlation test could not be applied (only 2 d had precipitation and visibility was usually unlimited).

Weather en route

Considering the Ottawa weather as weather en route, we tested for correlation between migration volume (i.e., the number of "goose echoes" recorded at Ottawa during 04:00–14:00) and weather variables measured at Ottawa at the hour of maximum migration. Weather variables included those considered for Syracuse as well as barometric pressure, change in barometric pressure from that on previous day, speed of upper air wind (regardless of direction), and expected ground speed using upper air winds. Upper air winds were estimated from 850 mB maps for 07:00 and the upper air winds at 07:00 for Albany, Montreal, and Maniwaki. Expected ground speed was the only variable significantly correlated with migration volume ($r_s = 0.611$, $P < 0.01$, N = 16 when using surface winds, and $r_s = 0.441$, $P < 0.05$, N = 16 when using upper air winds). Precipitation and visibility were not considered (all days had no precipitation and visibility was usually unlimited).

Our results are in general agreement with those of a 4-yr study of the spring migration of Snow Geese across southern Manitoba (Blokpoel and Richardson 1978), which indicated that the geese responded to following wind conditions, to fair weather, and to the complex of temperature-humidity-pressure variables.

Richardson (1978) discussed the adaptive significance of flights with various weather conditions. Flying with tail winds has obvious energetic advantages, especially for long-distance flights over inhospitable areas. For Canada Geese that nest in northern Quebec, flying with tail winds is highly adaptive, because their fat deposits are their only source of energy from the time of arrival on the breeding grounds until new plant growth is available (Hanson 1962).

Synoptic Weather and Migration Volume

The synoptic weather that affected the Ottawa area during the main migration period is briefly described. On day 1 (23 April) Ottawa was under the influence of a weak ridge of high pressure (R1) extending from the Atlantic Ocean to northern Quebec and a low (L1) was rapidly approaching from the west. The center of L1 crossed the Ottawa area on day 2 and moved further east on days 3 and 4. On day 3, L1 was still influencing the Ottawa area but on day 4 a new low (L2) had developed on the front to the east of Ottawa but to the west of L1. On days 5 and 6, L2 became stronger while hardly moving. During days 4–6 the weather in the Ottawa area was largely determined by L2. By day 7, L2 had lost some of its intensity and moved further east, while a new weak low (L3) was centered over Minnesota, far to the west. By day 8, L3 had stalled over Minnesota and by day 11 it had moved into Manitoba where it filled in. Thus, during days 7–11 the Ottawa area was positioned between lows far to the east (L2) and far to the west (L3). On days 7–9 the Ottawa weather was mainly influenced by L3 and a ridge of high pressure (R2) extending south from Hudson Bay, and on days 10 and 11 by a weak high (H1) to the south. The center of a new weak low (L4) had moved from the west into southwestern Ontario by day 12. From there L4 moved southeast, reaching the Atlantic Ocean by day 13. There L4 deepened while moving northeast. It had reached Nova Scotia by day 16. During days 13–16 the Ottawa area was situated more or less to the northwest of L4 and was also influenced by a stable high (H2) centered over Hudson Bay. On days 16–19, H2 moved south, reaching northwestern Ontario by day 17, Iowa by day 18, and Arkansas by day 19. On days 18 and 19 a low (L5) centered over Baffin Island far to the north of Ottawa extended its influence southward, while a new weak ridge (R3) had developed south of the Great Lakes on day 19. The Ottawa weather was mainly influenced by H2 on days 17 and 18, and by L5 and R3 on day 19.

The synoptic weather conditions for each of the 19 observation periods are plotted on a generalized weather map (Figure 3). Low-pressure areas are indicated by L, high-pressure areas by H, and ridges of high pressure by R. This map shows a weak low on the left and a strong low on the right. At the top and bottom are highs with ridges of high pressure extending southward and northward. Wind directions generally follow the isobars with the wind blowing clockwise around a high and a ridge, and counter-clockwise around a low.

For each day, the approximate synoptic location of Ottawa at 07:00 was determined using the weather maps for that hour. The migration volume for each

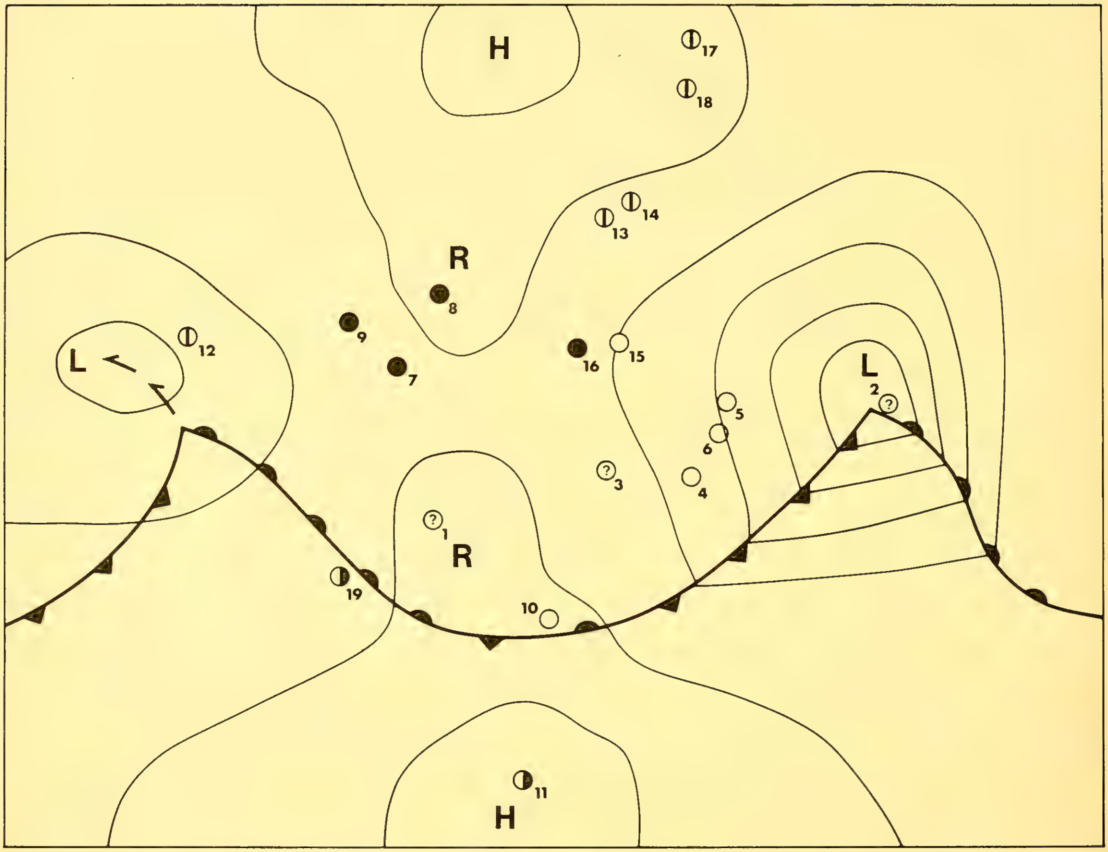

FIGURE 3. Generalized weather map showing high (H) and low (L) pressure systems, ridges (R) of high pressure, and fronts (warm, cold, quasi-stationary). Numbered circles show approximate locations of Ottawa relative to weather systems at 07:00 during 23 April–11 May 1975 (1 = 23 April, 2 = 24 April, etc.) and the number of "goose echoes" during 04:00–14:00: ○ = very light or no migration (0–80 echoes, $\bar{x}$ = 25, N = 5), ⦶ = light migration 81–160 echoes, $\bar{x}$ = 132, N = 5), ◑ = moderate migration (161–240 echoes, $\bar{x}$ = 208, N = 2), ● = heavy migration (> 240 echoes, $\bar{x}$ = 303, N = 4), and ⓘ = number of echoes unknown.

day (the number of "goose echoes" during 04:00–14:00) is also indicated on the map, except for 23–25 April (days 1–3), for which radar data were incomplete. Visual observations suggested heavy migration on day 1 and very light or no migration on days 2 and 3.

As Figure 3 shows, heavy and moderate migration occurred to the east of a low, under or near the west side of a ridge (days 1, 7–9, 19), near the center of a high (day 11), and far to the west of a low (day 16). Light and very light or no migration occurred to the west (days 3–6, 15) and east (days 2, 12) of a low, and to the east (days 17, 18), southeast (days 13, 14), and north (day 10) of a high. In other words, large numbers of geese often migrated with a light, warm, more-or-less southerly airflow, whereas few or no geese migrated with a cold, more-or-less northerly airflow. On the 2 d with calm, there was moderate migration (day 11) and very light to no migration (day 10).

Our results are in good general agreement with the findings of many other studies that birds migrating north in spring usually move in largest numbers "in the central and western part of a high, the eastern part of a low, or an intervening transitional area" (see review by Richardson 1978).

Three days (2, 12, 16) clearly deviated from this general pattern. On days 2 and 12 Ottawa, in the eastern part of a low, experienced southerly winds but only a few geese were migrating. On both days there was overcast and precipitation in Ottawa and/or Syracuse. It is likely that this rain and heavy cloud cover

suppressed the migration volume. Markgren (1963) and Blokpoel and Richardson (1978) reported that major goose flights are most frequent with no rain and little cloud. Day 16 was unusual in that heavy migration occurred in the face of a very light headwind. This probably happened because the geese were getting "behind schedule" as they had been delayed by several days of somewhat unfavorable weather (days 12–16 and, to a lesser extent, 10 and 11). As mentioned earlier, the last part of the 1975 spring migration was unusually late.

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Records of observations of staging and migrating Canada Geese in 1975 were provided by many volunteers, who were acknowledged by Gauthier et al. (unpublished report, 1976). B. Barrett allowed us access to the bird records of The Ottawa Field-Naturalists' Club. S. Browne, New York State Department of Environmental Conservation, provided results of an air survey in northern New York in spring 1972. H. A. McLeod, Ontario Ministry of Natural Resources, provided information on the usual chronology of Canada Goose migration across the Ottawa area. P. A. M. Angehrn and G. D. Tessier drafted the figures. J. E. Bryant, S. G. Curtis, W. J. Richardson, and three referees critically reviewed earlier drafts of the manuscript. Part of the study was carried out with financial support of Transport Canada and the National Research Council of Canada to the second author.

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Spawning Migrations, Age and Growth, and Summer Feeding of White and Longnose Suckers in an Irrigation Reservoir

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During the upstream spawning migration in spring 1978 of suckers into an irrigation reservoir diversion canal, the best correlation was between movement and 'stream temperature × discharge.' White Suckers (*Catostomus commersoni*) remained in the canal longer than Longnose Suckers (*C. catostomus*), and males of both species remained longer than females. The rates of White and Longnose Suckers returning downstream were 52.4% and 59.2% respectively, indicating high mortality, possibly from predation during spawning. Minimum age of spawning was 5+ for males and 6+ for females of White Suckers, and 4+ for males and 5+ for females of Longnose Suckers. In the lake, both species approached maturity at age 2 in males and age 3 in females. Annual growth in females was greater than in males after the age of first spawning. Cladocerans, mostly *Daphnia*, were major food items in the reservoir during the summer 1977, being 33.7% of White Sucker diet and 74.2% of Longnose Sucker diet over a 4-mo period. Tendipedidae were more important for White Suckers, contributing 21.0% of their food volume compared to 4.7% of food volume in Longnose Suckers. Feeding selectivity for *Daphnia* by both sucker species was apparent.

Key Words: *Catostomus commersoni*, *Catostomus catostomus*, spawning, age, growth, summer feeding.

Angling in southern Alberta has been supplemented in recent years by the highly successful 'pothole' lake fisheries created through annual introductions of hatchery-reared Rainbow Trout, *Salmo gairdneri* (Miller and Thomas 1956). This program includes the stocking of artificially-created irrigation water storage reservoirs, as well as natural lakes. Many of these lakes contain large populations of White Suckers (*Catostomus commersoni*), Longnose Suckers (*C. catostomus*), or both. Despite the wide distribution of White and Longnose Suckers throughout Canada (McPhail and Lindsey 1970; Scott and Crossman 1973) and in Alberta (Henderson and Peter 1969; Paetz and Nelson 1970), published information on ecological aspects of lake-inhabiting suckers (Raney and Webster 1942; Rawson and Elsey 1948; Rawson 1951; Brown and Graham 1954; Harris 1962; Geen et al. 1966; Bailey 1969; Beamish 1973, 1974; Lalancette 1977; Verdon and Magnin 1977a, b) has been mainly restricted to natural lakes.

The objective of this study was to document specific features of two sympatric sucker populations in Paine Lake, a typical southern Alberta irrigation reservoir, including the following: inflow stream spawning migrations, age and growth characteristics, and summer food habits. This information was required to consider the selective removal of suckers during the spawning migration as a possible method of improving growth rates and angler harvest of stocked Rainbow Trout.

Study Area

Paine Lake is located in southwestern Alberta (49°06'N, 113°39'W) about 3 km from the eastern portion of Waterton Lakes National Park. The surrounding open foothills landscape, characterized by strongly rolling prairie and deeply incised river valleys, is contained in the Western Interior Plains physiographic region (Bird 1972). This 244-ha reservoir has a maximum depth of 6.4 m although most of the lake is from 2 to 6 m deep. Irrigation water is supplied as required to Paine Lake from the Belly River to the west, through a 5-km diversion canal. The other inflow stream, Mami Creek, is blocked to fish passage by beaverdams. Paine Lake was treated with toxaphene in 1962 to remove excess numbers of suckers and again rehabilitated in 1969 by artificial drawdown in an attempt to induce winterkill.

Materials and Methods

From May to August 1978, upstream and downstream box traps separated by a barrier of wooden screens were installed in the diversion canal 1.4 km upstream of the lake. Both traps were checked daily at every 2–3 d during the latter part of the run. Suckers passing through the upstream trap were enumerated according to species, sex, and state of maturity. All fish were marked either with a sequentially numbered metal opercular tag (Monel, Size 1) or by removing the distal portion of one pectoral fin. From every tenth fish, up to 20 fish of each sex and species per day,

fork length was recorded, and pectoral fins and dorsolateral scales were removed for age determination. In late May, cursory examinations were made by visual observation and by seining inshore areas to assess the extent of lake spawning.

Suckers were aged by microscopic examination of transverse sections approximately 0.5 mm thick obtained from near the base of the first two or three pectoral fin-rays using a jeweller's saw. Comparative aging was done using scales and fin-rays on all fish up to 5+ yr to establish the presence or absence of false annuli in the fin-ray (Beamish 1973).

Tag numbers were checked when suckers were recaptured in the downstream trap to determine the number of days fish remained upstream. Tagged and fin-clipped fish in the downstream trap were enumerated and released below the barrier. Opercula of all unclipped fish were checked for tag loss. Occasional unmarked suckers in the downstream trap were fin-clipped before release.

Water temperature in the canal was continuously recorded with a submersible thermograph (Ryan, Model F-30). Stream discharge data for the canal were supplied by Water Survey of Canada, Department of the Environment. Since both traps were usually checked in the morning, linear correlations were made on numbers of suckers in the traps, and temperature and discharge of the previous day.

A gill net gang consisting of 13.7 m of 25-mm, 18.3 m of 38-mm, and 22.9 m each of 51-, 64-, 76-, 89-, 102-, and 114-mm stretched mesh was set for 14–16 h overnight, five times during July and August 1978 at different locations throughout the lake. Annual growth curves were established by combining age-length data for suckers from the upstream trap and the lake test nets. Population estimates in the lake from returns of marked suckers were determined by the modified Schnabel formula (Ricker 1975).

Digestive tracts from both sucker species in the lake were obtained from May through August 1977 with 23-m gill nets of 64-mm and/or 76-mm stretched mesh set for about 0.5 h during daylight hours. Because suckers lack a true stomach (Weisel 1962), the anterior 18–25 cm of the digestive tract was utilized. Initially, digestive tracts were injected and preserved with 70% isopropyl alcohol, later opened and the volume of contents allotted a certain point value according to the degree of fullness (Hynes 1950; Thompson 1959). When it became apparent that digestive tract contents contained a high proportion of digested matter, the food point value was assigned immediately upon capture, and the anterior few centimetres of undigested food material were removed and preserved in 10% formalin. After classification of food items, each item category was allotted a portion of the total points assigned to that particular tract according to the estimated volume contribution of that category in the subsample (Thompson 1959).

Results and Discussion

Spawning Migrations

White Suckers commenced migrating upstream in the diversion canal in late May and continued for 51 d. The Longnose Sucker migration lasted for 43 d from the beginning of June. A total of 8239 White Suckers and 3726 Longnose Suckers passed through the upstream trap, with 94% of the run occurring from 25 May to 1 July, inclusive. During that period, a moderate correlation was evident between White Sucker movement and 'maximum daily water temperature × daily discharge' ($r = 0.48$, $n = 37$), which was higher than that for water temperature either as daily maximum ($r = 0.24$) or mean ($r = 0.37$) or daily discharge ($r = 0.36$) alone. Similarly for Longnose Suckers, the highest correlation was apparent between 'mean daily water temperature × daily discharge' ($r = 0.37$); there was less correlation between movement and daily discharge ($r = 0.32$) and none between movement and water temperature only ($r < 0.1$). Although canal temperature was suitably high (>10°C) to initiate sucker movement (Geen et al. 1966) in late May, suckers did not first move into the trap until there was a sudden rise in stream discharge to above 0.08 $m^3 \cdot s^{-1}$.

Geen et al. (1966) found no relationship between discharge and spawning movements of suckers and concluded that the single critical factor initiating the spawning migration was water temperature. This view is supported by others for movement into streams by lake-inhabiting suckers (Raney and Webster 1942; Rawson and Elsey 1948; Brown and Graham 1954; Harris 1962; Bailey 1969). In contrast, Walton (1979) recently reported that stream discharge was more important in initiating spawning movement. From this study, it appears that both water temperature and discharge are important for sucker migration, with initiation of movement depending on which factor is limiting in the spring.

Initially, more male suckers than females were present in the canal spawning population. Near the end of the run, however, females outnumbered males by 1.6:1.0 for White Sucker and 1.7:1.0 for Longnose Sucker. Raney and Webster (1942) and Bond (1972) reported a 1:1 sex ratio in spawning White Suckers. Previously for Longnose Suckers, females outnumbered males by 2.1:1.0 (Geen et al. 1966) or as many as 10:1 (Harris 1962). Consistency of sex ratio in spawning populations of suckers is apparently not universal.

The average length of time spent in the canal by spawning suckers was greater for White Suckers

(20.8 d) than for Longnose Suckers (17.2 d), with males of both species remaining in the canal longer (White Suckers 22.6 d, Longnose Suckers 20.5 d) than females (White Suckers 19.7 d, Longnose Suckers 15.3 d). Generally, suckers that were early in the run stayed in the canal longer and were not as ripe as those that migrated later.

The major peak of downstream White Sucker movement was in early July. Longnose Suckers returned downstream more consistently from mid-June through early July than did White Suckers. The highest correlation ($r = 0.48$) existed between downstream movement of White Suckers and stream discharge. In close agreement with Geen et al. (1966), Longnose Suckers appeared in the downstream trap 6 d after the initial upstream migration while White Suckers were present 13 d after moving upstream. By late August, only 52.4% of the White Suckers and 59.2% of the Longnose Suckers had returned through the downstream trap to the lake. The return rate of fin-clipped fish was higher (White Suckers 58.6%, Longnose Suckers 61.3%) than for the tagged fish (White Suckers 33.7%, Longnose Suckers 47.7%). Tag loss was negligible ($< 0.1\%$). By comparison, Geen et al. (1966), in two successive years, reported a spawning mortality of 11% and 28% for Longnose Suckers, and 15% and 20% for White Suckers, which they considered low. Predation may have accounted for high losses of canal spawners, particularly when the flow was low. Various mammals and birds predatory to fish, especially Great Blue Heron (*Ardea herodias*), were observed on numerous occasions around or near the canal during the spawning run. Fresh scars, apparently caused by birds, were observed on some sucker specimens returning downstream. Previously, Brown and Graham (1954) noted a significant loss from predation of tagged Longnose Suckers by resident pelicans in Yellowstone Lake, suggesting the fish were in a weakened state from being held in the trap prior to release.

Based on estimates made from 121 recaptured marked fish (1.9% of marked stock at large), only 7.2% of the total White Sucker population and 24% of the total Longnose Suckers in the lake migrated through the trap to spawn upstream. An additional large number of Paine Lake suckers likely spawned in the lower reaches of the diversion canal. This was confirmed by observations of many White Suckers actively spawning just below the trap during the peak of the run. But the proportion of the sucker population which may have utilized the shallow inshore areas of the lake proper for spawning grounds remains unknown. Seine-net hauls in inshore areas around the lake revealed no evidence of lake spawning. Visual observations in shallow water around the lake were impaired by turbidity.

Age and Growth

The minimum age for White Suckers spawning in the canal was 5+ for males and 6+ for females. For Longnose Suckers, minimum spawning age was 4+ for males and 5+ for females. A high ratio of 7+ fish (73% and 52% of male and female White Suckers, 45% and 68% of male and female Longnose Suckers, respectively) were present in the spawning migration samples. Few spawners were reported older than 11+ yr. The scarcity of suckers older than 8+ yr indicates that the artificially-induced winterkill in 1969 was relatively effective. Subsequent survival of the 1971 year class must have been high to account for the unusual proportion of 7+ fish.

Paine Lake White Suckers first spawned a year older than those from a rapidly growing population in Ontario reported by Beamish (1973) using the same aging technique. Similar ages of first spawning have been described by other authors (Raney and Webster 1942; Brown and Graham 1954; Geen et al. 1966; Bailey 1969) using scale aging.

Both White Suckers and Longnose Suckers from test nets were mature or approaching maturity at age 3 for females and age 2 for males. Paine Lake suckers evidently become mature 1–2 yr prior to migrating up the diversion canal to spawn. In two Ontario lakes, White Suckers were mature 1 yr prior to spawning (Beamish 1973) and in Great Slave Lake, Longnose Suckers were mature 2 yr in advance of spawning (Harris 1962).

For both species, growth rates of male and female suckers were similar up to the age of first spawning (Figures 1, 2). After age 6 in White Suckers and age 5 in Longnose Suckers, annual growth was greater in females than in males. Differential growth between sexes is typical for lake-inhabiting White and Longnose Suckers (Raney and Webster 1942; Brown and Graham 1954; Beamish 1973) with the difference in length by sex increasing with age (Verdon and Magnin 1977a). In comparison with growth of White Suckers in other North American lakes described by Beamish (1973) and Verdon and Magnin (1977a), Paine Lake suckers are moderately fast growing populations.

Summer Feeding

Cladocera, mostly *Daphnia* spp., were major food items for the 265 adult White and 85 adult Longnose Suckers from Paine Lake examined during the 1977 summer (Figure 3). They comprised 33.7% of White Sucker food volume and 74.2% of Longnose Sucker food volume for the 4-mo season. Tendipedidae larvae were present more often and to a greater extent in White Sucker digestive tracts (21.0%) than in Longnose Suckers (4.7%). Similarly, Cladocera and chironomids were of primary and secondary importance, respectively, as White Sucker food items in two Ont-

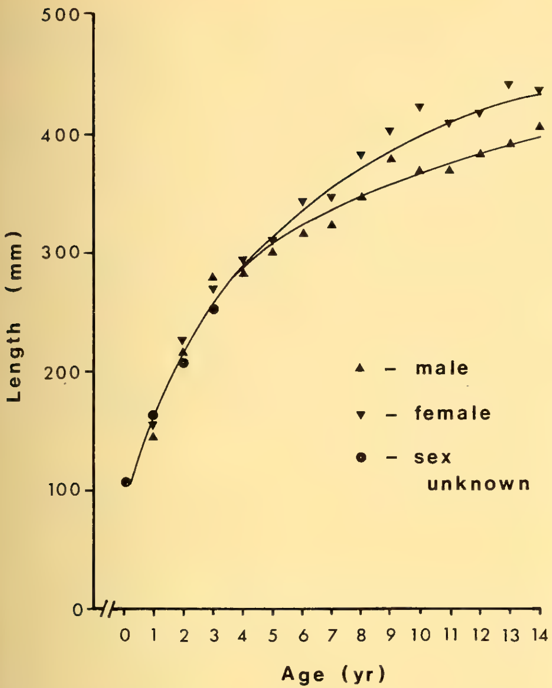

FIGURE 1. Growth curves of male and female White Suckers from Paine Lake in 1978 (includes both diversion canal spawners and test net captures).

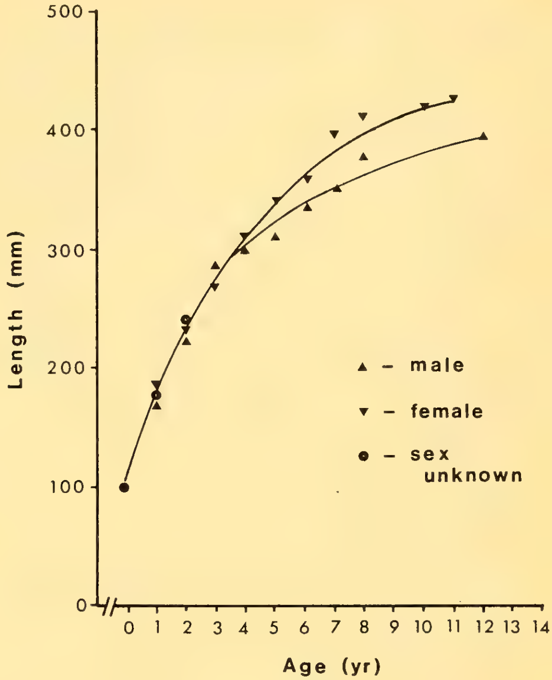

FIGURE 2. Growth curves of male and female Longnose Suckers from Paine Lake in 1978 (includes both diversion canal spawners and test net captures).

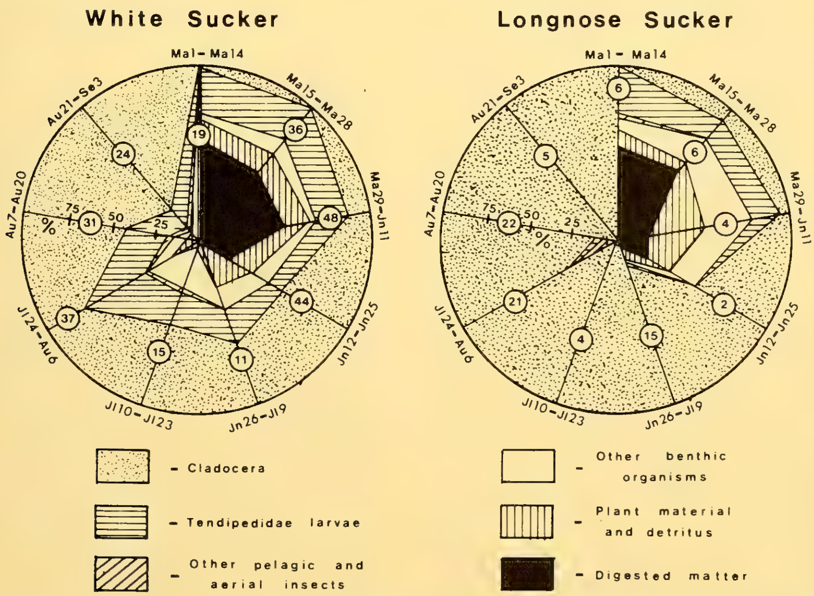

FIGURE 3. Percentage contribution by volume of food items to total digestive tract contents of White and Longnose Suckers from Paine Lake at 2-wk intervals for a 4-mo period in 1977. Radius of circle represents 100%. Interval sample sizes are presented on the radii. (Ma = May, Jn = June, Jl = July, Au = August, Se = September).

ario lakes (Beamish 1974), whereas Lalancette (1977) found that cladocerans and copepods accounted for the majority of food items ingested by White Suckers in a small Quebec lake. On twoi sampling dates, *Daphnia* comprised 100% of the digestive tract contents of Longnose Suckers. In Yellowstone Lake, Brown and Graham (1954) also reported that *Daphnia*, as well as *Gammarus*, followed by Tendipedidae, were the most important Longnose Sucker food items.

Copepods, which are common with *Daphnia* in Paine Lake zooplankton (Barton and Bidgood 1980), were virtually absent in digestive tract contents of both sucker species during the summer season. Such selectivity for Cladocera over other zooplankters has been noted previously in White Suckers (Lalancette 1977) and in Longnose Suckers (Rawson and Elsey 1948). Lalancette (1977) also showed that preference for cladocerans over copepods was evident throughout 12 mo of the year.

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Late Summer Activity Changes in Populations of Eastern Chipmunks (*Tamias striatus*)

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Hypotheses regarding an unexplained summer lull observed among Eastern Chipmunk (*Tamias striatus*) populations are reviewed, discussed, and evaluated in light of new data. I have added a new hypothesis based on burrow preparation, and reason that the basic determinant of late summer activity is the interaction between the nature of available food (storable or nonstorable, good or poor quality), the habitat dispersion of the food, and cache (and burrow) condition. Botfly (*Cuterebra emasculator*) parasitism is probably an important co-determinant of population activity when infestation is severe.

Key Words: *Tamias striatus*, Eastern Chipmunk, activity patterns, summer lull, food availability, botfly parasitism.

The aboveground activity of Eastern Chipmunks (*Tamias striatus*) is usually interrupted by a pronounced activity lull during late summer. The lull is typically a 3- to 4-wk period of inactivity in August (Dunford 1972). Many explanations for this lull have been proposed, but its biological significance remains unknown. My objectives in this paper are to review hypotheses and evidence for the lull, to present my field and laboratory data, and to integrate the most viable explanations and suggest directions for future study.

The hypotheses proposed to explain the summer lull are as follows: (1) high temperature stress reduces *Tamias* activity and/or induces estivation (Allen 1938; Smith 1942; Panuska and Wade 1957); (2) food shortages reduce *Tamias* activity (Ryan and Larson 1976; Elliott 1978; M. J. Lacki, M. J. Gregory, and P. K. Williams, Department of Biology, University of Dayton, Ohio, unpublished data); (3) the lull represents a period of post-reproductive quiescence (Schooley 1934; Yahner 1977); (4) botfly (*Cuterebra emasculator*) parasitism reduces *Tamias* activity (Elliott 1978); and (5) there is no true lull; relative lack of vocalizations during late summer exaggerates observational sampling error (Schooley 1934; Yerger 1955).

Meteorologic influences (temperature, humidity, precipitation) appear inconsequential in the occurrence of a late summer lull (Thibault 1969; Dunford 1972). Captive chipmunks exposed to natural environmental temperatures entered torpor in winter and spring but did not estivate in summer (Wang and Hudson 1971). Richter (1978) presented data supporting the contention that the activity–inactivity phases of the Eastern Chipmunk are controlled by a yearly clock which is set by, but not dependent on, photoperiod. The winter inactivity phase is clearly shown by his data, but no other inactivity period is evident. Dunford (1972) rejected three hypotheses: the temperature stress hypothesis, by showing that ambient temperatures during June, July, and August were similar and fell within his proposed optimum range although the lull occurred as anticipated; the food shortage hypothesis, because he found mast (an important component of the diet of *Tamias*) to be abundant during the lull; and the post-reproductive quiescence hypothesis, because he could find no evidence of a correlation between mating activity and the onset of the lull period.

Methods

My assessment of changes in population activity is based primarily on observations of two Eastern Chipmunk populations. The first was located in a 5-ha section of deciduous forest in Strouds Run State Park, Athens County, Ohio. I was present on the study area for approximately 45 h per month (May through October 1975), during which time a record was kept of captures, sightings, vocalizations, and relative abundance of food. Study periods were not always full days, but weekly effort was distributed fairly evenly between 07:30 and 17:00. A little over half the area at this site was poor chipmunk habitat (see Svendsen and Yahner 1979) and was seldom used by chipmunks.

The second population inhabited a 1.6-ha peninsular section of deciduous forest, surrounded by pasture, in the Sulphur Spring Hollow area of Monroe County, Indiana. This population was live-trapped on 2 non-consecutive days per week (May through October 1979) except for the second week of July. Traps were set at 07:00 and checked at 12:30 and again at 17:00. A record was kept of captures, sightings, and relative abundance of food.

A third population, in a forest near Lake Monroe, Monroe County, Indiana, was casually observed dur-

ing the summer of 1979, and trapped (same method as the Sulphur Spring population) between 22 July and 11 August.

The traps were 8 × 8 × 24-cm aluminum live-traps baited with sunflower seeds. For each population, 20 traps were placed in areas frequented by chipmunks along a trapline that ensured coverage of the chipmunk-inhabited area. Study was suspended on rainy days. Live-trapping and observational data were used to quantify activity; the captures and sightings of individuals expressed as a rate (number active per hour) provided an index of chipmunk activity (ICA). Local climatological data were obtained from the Departments of Geography at Ohio University and Indiana University.

In the laboratory, the running wheel activity of six chipmunks parasitized by botfly larvae was compared to that of six without bots. These chipmunks were captured in areas near the Sulphur Spring study area in August and September and individually held in running wheels at 21° C under natural photoperiod. Water and lab chow were provided *ad libitum*. Wheel revolutions were recorded daily at 17:00; after eight values (total revolutions per day) were obtained the chipmunk was released at its capture site. The test procedure was repeated for four of the parasitized chipmunks subsequently recaptured without bots. The first count of revolutions per day was discounted in analyses as an adjustment value.

TABLE 1—Composition of the Eastern Chipmunk populations at Strouds Run (SR) and Sulphur Spring Hollow (SSH). Age class was determined by body weight and pelage characteristics (see Wrazen and Svendsen 1978). The juveniles were residents (determined by stable exclusive occupation of a burrow). Females were categorized as breeding if they were pregnant or lactating when captured

Category	Population SR	Population SSH
Adult female	13	10
Adult male	9	11
Juvenile female	5	4
Juvenile male	5	2
Breeding females, spring	3/11[a]	5/8[a]
Breeding females, summer	0/10[a]	3/5[a]
Total no. captured	32	27

[a]Breeding females/total adult females captured in that season.

Results and Discussion

The Strouds Run population described in Table 1 did not exhibit the typical 3- to 4-wk August lull. The mean (± SE) weekly ICA (number active per hour) was maintained during 18 wk of spring and summer (0.96 ± 0.06; range 0.60 to 1.33) but dropped abruptly to the lowest level recorded during the first week of September (0.18). Chipmunks were not seen or heard during that week, although weather was considered ideal for trapping. The chipmunks reappeared the following week; the mean (±SE) weekly ICA for the 7 wk prior to winter retirement was 0.60 ± 0.08 (range 0.33 to 1.00). These data are based on 5420 trap-hours and 324 observation-hours of study. The following potentially relevant conditions existed for the Strouds Run population: none of the females in the population raised a summer litter, summer food sources were abundant during mid-August but relatively scarce during late July and early August, and botfly parasitism was limited to two individuals (for additional details, see Wrazen and Svendsen 1978).

The mean (± SE) weekly ICA of the Sulphur Spring population described in Table 1 was 0.76 ± 0.08 during 11 wk of spring and summer, then dropped to 0.22 ± 0.05 between 22 July and 1 September. During this latter period, which was considered a lull, chipmunks were not seen or heard in the study area or nearby woodlands. After 1 September the ICA returned to July levels and the presence and movements of individuals were again noticeable. These data are based on 8640 trap-hours and 250 observation-hours of study. During the lull, food was at least as abundant as before the lull. Three females raised summer litters. Botfly parasitism was extensive and first appeared in this population between 15 and 21 July (four of the six individuals captured during that week carried bots). Five of the eight individuals captured during the lull carried at least one bot; 6 of 12 captured in nearby woodlands were infested. Hickory nuts (*Carya* spp.) began falling during mid-July and a very large Basswood (*Tilia americana*) mast crop fell between 29 July and 18 August.

Aboveground activity of the Lake Monroe population ceased abruptly on 21 July, coincident with the initial fall of mast (immature, diseased, or infested by insects) from hickory and American Beech (*Fagus grandifolia*) trees. By 29 July sound mast had begun falling heavily and accumulated on the forest litter and in depressions, without apparent utilization by sciurids. Small piles of sunflower seeds placed at burrow entrances also remained undisturbed. No chipmunks were seen, heard, or trapped between 22 July and 11 August, when study at this site was terminated. Because no captives were obtained, the extent of botfly parasitism could not be determined.

No adverse or unusual weather conditions obtained for any population during the period of inactivity. Climatological data (Table 2) were compared and the null hypotheses that there were no differences among periods or populations were tested by analyses of variance. For the Sulphur Spring population, the lull

TABLE 2—Climatological data (mean ± SE) for the Sulphur Spring Hollow (SSH) and Strouds Run (SR) populations during selected periods

Period	Population	Maximum daily °C	Mean daily °C	No. rainy days/wk
Pre-lull	SSH	27.1 ± 0.4	21.5 ± 0.4	2.0 ± 0.4
Lull	SSH	27.9 ± 0.6	22.9 ± 0.5	2.7 ± 0.7
August	SR	28.5 ± 0.5	23.2 ± 0.5	2.0 ± 0.6
Pre-lull week	SR	29.6 ± 0.4	24.5 ± 0.7	
Lull week	SR	26.7 ± 0.9	21.2 ± 0.7	
Post-lull week	SR	22.7 ± 1.3	16.2 ± 1.2	

period was not warmer than the pre-lull period whether maximum daily temperatures ($P > 0.25$) or mean daily temperatures ($P > 0.05$) were compared. There were no differences ($P > 0.50$) in maximum or mean temperatures between the Sulphur Spring lull and the Strouds Run August period. There were significant temperature differences ($P < 0.001$) among the pre-lull, lull, and post-lull weeks of the Strouds Run population; the lull week was cooler than the week before and warmer than the week following. There were no detectable differences ($P > 0.75$) among periods in the number of rainy days per week. Thus, no evidence was found that long-term chipmunk activity reduction is a function of late summer weather.

Because Eastern Chipmunks are considered primarily herbivorous (Hall and Kelson 1959), the food shortage hypothesis is attractive: August is a period when preferred plant food is relatively unavailable (Elliott 1978; Wrazen and Svendsen 1978). But fungi and animals become significant food items for *Tamias* during summer (Yerger 1955; Forbes 1966; Elliott 1978; Wrazen and Svendsen 1978), and these may well be available in sufficient amounts during August. Also, chipmunks forage effectively for less obvious plant resources such as bulbs (Elliott 1978; Wrazen and Svendsen 1978). Proponents of the food shortage hypothesis (Ryan and Larson 1976; Elliott 1978; M.J. Lacki, M.J. Gregory, and P.K. Williams, unpublished data) have noted that the presence of natural or introduced storable food eliminates the summer lull, and reasoned that the absence of food will result in a lull. Dunford's (1972) observations do not support this reasoning because the lull occurred despite the presence of a large crop of beechnuts. The Lake Monroe and Sulphur Spring populations I studied were inactive while fallen mast was superabundant. *Tamias* is known to respond to food restriction (or weight loss) with increased activity (Allen 1938; Panuska 1959; Vincent et al. 1977; Yahner 1977; Estep and Peacock 1979); food restriction does not induce torpidity in *Tamias*, as it does in other sciurids (Wang and Hudson 1971). If food shortage leads to inactivity, a lull during late July and early August would have been probable for the Strouds Run population; however, no decrease in activity occurred.

The mating seasons for *Tamias* in Ohio are the periods from February to April and from June to August (Yahner and Svendsen 1978). Yahner and Svendsen (1978) noted that both mating seasons are followed by lulls. Yahner (1977) suggested that an undetermined endogenous factor related to reproduction may be involved in activity reduction. Summer (July) mating activity occurred in the Strouds Run population but no lull ensued. Females may not have retired to burrows because none became pregnant, but the reproductively active males also continued to be active through August. When a lull is reported, both sexes are inactive, thus the involvement of nonreproductive factors is probable. A detailed study of the reproductive physiology of *Tamias* is necessary before this explanation can be fully evaluated.

Bennett (1973) demonstrated a marked reduction in the running wheel activity of four Eastern Chipmunks, each with multiple botfly lesions, during and after the time when the larvae were leaving the hosts. Elliott (1978) noted that infestation of *Tamias* populations occurs in late summer and early autumn and may contribute to a reduction of chipmunk activity; Bennett (1955) recorded the greatest incidence of botfly lesions during the month of August. Seidel (1960) did not detect a summer lull among populations having a low infestation rate (1.6%).

The running wheel performance of chipmunks with and without bots (Table 3) was analyzed by analysis of variance. Parasitized chipmunks were less active than unparasitized whether comparing mean revolutions ($P < 0.005$) or maximum revolutions ($P < 0.001$). The mean (± SE) change in revolutions following loss of the bots was +7805 ± 1871 (paired t-test, $P < 0.05$). These data implicate botfly parasitism as a major cause of the activity reduction of the Sulphur Spring population. The lull coincided precisely with the period of infestation.

The hypothesis suggesting that the false impression of a lull occurs when the vocalization frequency drops was evaluated for the Strouds Run population by comparing the number of chipmunks captured in live-

TABLE 3—Running wheel performance of Eastern Chipmunks unparasitized or parasitized by botfly larvae, given as revolutions per day (mean ± SE) over a 7-d period. Each parasitized individual carried a single inguinal bot, except MA1 which carried five. MA3 lost the bot during the test and thus provided only four revolution values. F = female, M = male

	Revolutions per day (mean ± SE)	
Chipmunk	Parasitized	Unparasitized
FA1	7912 ± 1173	15901 ± 1323
FA2		14725 ± 1912
FA3		14940 ± 2840
FA4		14187 ± 2241
MA1	2959 ± 432	5415 ± 581
MA2	3246 ± 487	
MA3	2594 ± 443	13099 ± 2408
MA4	2277 ± 494	
MA5	9673 ± 3316	19943 ± 4869
MA6		12767 ± 3483
MA7		29898 ± 2993
MA8		16615 ± 1365

traps per hour with the number of vocalizations recorded per hour for July, August, and September (Table 4). Weekly capture rates did not differ among months ($P > 0.05$) but August vocalization rates were lower than those of July and September ($P < 0.01$), as determined by the Kruskal-Wallis test. Because vocalizations facilitate visual observations by attracting attention to the caller, visual estimates of activity might tend to underestimate late summer activity of the ordinarily inconspicuous *Tamias*.

In the population studied by Yahner (1977), chipmunks that lost weight in late summer remained active during the lull, apparently to maintain or increase bodily energy reserves through extensive foraging. To test for this effect, I determined the median body weight for each of the three individuals from each population with the greatest number of capture weights including August weights, and compiled a table showing the number of capture weights above and below the median for each individual by seasonal periods (Table 5). The data were analyzed by multi-way tests of independence (Sokal and Rohlf 1969). The factors Chipmunk, Weight relative to median, and Period were found to be jointly independent for the Sulphur Spring population ($P > 0.10$) but not for the Strouds Run population ($P < 0.005$). Weight status was not independent of period for the Strouds Run population ($P < 0.005$); chipmunk weights tended to be below median during August. Thus, the continued activity of the Strouds Run population through summer does seem to be correlated with low chipmunk weights. The Sulphur Spring population presents a problem in that the three individuals, although active during the lull, were not below median weight. This suggests that the critical body weight below which energy deficit becomes serious may vary among populations or with the sizes of individuals, or that other factors must be considered. Eastern Chipmunk vocalizations are thought to be associated (not exclusively) with conspecific trespass (Dunford 1970). Lack of vocalizations in the Strouds Run population during August (Table 4) may mean that foraging and other activities during August were confined to the area near the home burrow. Diets at this time were 30–50% animal matter (the range for this population was approximately 10–40% for other times of the year; Wrazen and Svendsen 1978) and very little of the consumed material may have come from a cache (unpublished data). This population may then have been active to maintain body reserves because caches had been depleted by August. The quality of available food was evidently such that body weights could not be increased. Movements were apparently restricted to the core area, reflecting a reduced energy expenditure and/or abundant core area food. Forsyth and Smith (1973) did not report a lull but home-range overlap was notably reduced during late August. The three Sulphur Spring individuals may have been active during the lull because of depleted caches and depletion of core area food.

One hypothesis not heretofore proposed to explain a late summer lull concerns preparation of the burrow for autumn food storage. Hoard consumption may be part of a necessary "house-cleaning" procedure prior to mast-fall, obviating the need for extensive foraging. Annual burrow preparation during late summer is

TABLE 4—Capture and vocalization rates for the Strouds Run population during three late-season months

Month	Hours of study	Total captures	Capture rate (no./h)	Total vocalizations	Vocalization rate (no./h)
July	51	46	0.90	23	0.45
August	40	34	0.85	0	0
September[a]	30	13	0.43	24	0.80

[a]Excluding the first week.

TABLE 5—Weight status of Eastern Chipmunks from two populations (SR = Strouds Run, SSH = Sulphur Spring Hollow) captured before, during, and after the summer lull or expected lull period (August). F = female, M = male

Population	Chipmunk	Median weight, g	Ratio of capture wts above/below individual's median wt		
			pre-Aug.	Aug.	post-Aug.
SR	F 1	89.0	11/7	0/8	6/1
	F22	81.0	5/7	0/2	4/0
	M24	80.5	2/3	2/3	2/1
			pre-lull	lull	post-lull
SSH	F 1	107.5	1/6	5/3	7/4
	M15	114.0	7/4	2/1	2/6
	M17	103.5	5/7	6/1	4/8

probably a necessity because a sound cache is critical for chipmunk winter survival (Brenner and Lyle 1975), some food is likely to be present in the cache all year (Elliott 1978; Wrazen and Svendsen 1978), and microbial invasion and cache deterioration are inevitable (Janzen 1977). It is known that the subterranean caches of *Tamias* are subject to sprouting, rotting, and insect attacks, and Elliott (1978) observed that larval damage of stored mast is most severe during late July. In addition to hoard consumption, preparatory activities would include the ejection of decomposing material and isolation of tunnels or chambers containing objectionable material. Little field work has been done with regard to Eastern Chipmunk subterranean activity, but there is evidence that preparatory activities do occur. Extensive refilling of tunnels with soil was reported by Panuska and Wade (1960) and Thomas (1974). Panuska and Wade (1960) reported a chamber containing refuse (a chipmunk carcass) which had been sealed off by the burrow's current occupant; Allen (1938) found burrow "refuse dumps" (side pockets), sealed with soil plugs, containing inedible food particles and feces; and Seidel (1960) also found "dumps" packed with inedible food. R.H. Yahner (Department of Entomology, Fisheries and Wildlife, University of Minnesota, St. Paul, personal communication) regarded the appearance in late summer of freshly excavated soil at a burrow entrance as a sign that the occupant would be more active (trappable) in subsequent weeks. During a laboratory study (in preparation) of the hoarding behavior of Eastern Chipmunks, I noted house-cleaning kinds of activity. Hoarding behavior of captives was studied for 45 d in July-August and for 15 d in October. Cages with burrow attachments were used. Considerable intercompartmental shifting of cached items occurred, and 13 deliberate ejections of a portion of cached items from the burrow were observed for 7 of 16 individuals between 27 July and 23 August. Ejections were not observed during the October period. Other preparatory activities could not be studied because the cages offered no opportunity for digging.

General Discussion

Of the five hypotheses proposed by previous investigators to explain population activity reduction, only the parasitism hypothesis was supported by the present study. The observational error hypothesis may explain some, but not all, of the reported lulls. There is at present no evidence that endogenous factors (reproductive or a circannual cycle) are responsible for the occurrence of summer lulls, although further investigation along these lines is warranted. Botfly parasitism may cause noticeable decrements in late summer and early autumn population activity. The Sulphur Spring population lull coincided with a relatively extensive botfly infestation. The Strouds Run population was essentially unparasitized by botfly larvae and maintained spring-summer levels of activity through August. This population "disappeared" for the first week of September, however, suggesting that some period (which may be short or long) of restricted aboveground activity is inevitable at this time of year. Many of the reported lulls involve the simultaneous disappearance of a large number of individuals. A possible explanation for this synchrony is that the premature fall of diseased and insect-infested mast, which varies in timing from year to year, serves as a cue for initiation of the lull (cf., Boucher and Sork 1979). This effect could have occurred in the Sulphur Spring and Lake Monroe populations. Short lulls may be undetectable when individuals are asynchronous in "disappearance" and only general population activity is noted. The burrow preparation hypothesis provides at least a partial explanation of the late summer disappearance, because preparatory activities are probably necessary at this time (i.e., regardless of other factors, a period of retirement will occur). Because the cache is crucial to chipmunk survival, the basic determinant of late

summer activity may be the interaction between the nature of available food (storable or nonstorable, good or poor quality), the habitat dispersion of the food, and cache (and burrow) condition. Chipmunks with burrows not containing edible food and/or individuals with a bodily energy deficit would be forced to remain active aboveground during the period between mating and burrow preparation or mast storage. Chipmunks with access to edible caches or having good-quality food supplies close to the burrow may be "permitted" to retire. Botfly parasitism is likely to be an important co-determinant of activity when infestation is severe.

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Morphology and Diet of Young-of-the-year Burbot, *Lota lota,* in the Ottawa River

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Hanson, J. M. and S. U. Qadri. Morphology and diet of young-of-the-year Burbot, *Lota lota,* in the Ottawa River. Canadian Field-Naturalist 94(3): 311–314.

In August and September 1979, 41 young-of-the-year Burbot, *Lota lota*, were collected with a D.C. electrofisher in shallow water of the Ottawa River, near Ottawa, Ontario. The fish provide the second record of capture of young Burbot in eastern Canada outside of the Great Lakes. Head length was significantly longer and the first dorsal fin length, preanal length, postpectoral length, and predorsal length were shorter for juvenile Burbot compared to adults. The anal fin was white with a thin black edge and the pectoral fin rays were black. Young Burbot attained a mean total length of 87.3 mm and weighed 5.6 g in August and were an average of 102.9 mm long and weighed 7.6 g in September. The length-weight relationship was log WT = 2.579 log TL – 4.299. Amphipods were the most important food item but 28.6% of the young Burbot ate darters (*Etheostoma* spp.) in September.

Key Words: Burbot, *Lota lota*, juveniles, body proportions, coloration, food organisms, morphology (organisms), length-weight relationship, amphipods, darters, Ottawa, Ontario, Ottawa River.

The Burbot, *Lota lota*, has long been regarded as a competitor of commercially important fish (Dymond 1926; Bailey 1972) and as a nuisance because it eats fish caught in gillnets (Branion 1930) and trapnets (Hewson 1955). There was, however, a significant winter fishery in Wyoming (Bjorn 1940). McCrimmon and Devitt (1954) attributed the scarcity of published studies on the ecology of Burbot to the relative insignificance of its role in sport or commercial fisheries. Although Burbot has a wide distribution in North America, the young-of-the-year are seldom caught. Thus, little information is available on the diet of juvenile Burbot and studies on their morphology are lacking.

This study describes the occurrence, appearance, some aspects of growth, and diet of young-of-the-year Burbot in the Ottawa River, near Ottawa, Ontario.

Materials and Methods

Young-of-the-year Burbot were caught along the south shore of Kettle Island and the north shore of Upper Duck Island (45°28′10″–45°28′15″N, 75°36′–75°38′W) in the Ottawa River. A backpack Type VII Electrofisher (Smith-Root Incorporated, Vancouver, Washington, USA) was used for all collections. The bottom was sand with beds of *Elodea canadensis* and *Vallisneria americana* starting at about 0.3-m depths and 5 to 10 m from the banks. There were a few stumps and sunken boards between the shore and the start of the weedbeds.

Sampling was done at weekly intervals from 1 August to 30 September 1979. The specimens were immediately weighed (to 0.01 g) and total length (in millimetres) was measured. Color patterns of the belly, lips, head, sides, and fins were recorded for 30 specimens within 24 h of capture. Morphological measurements were made following Hubbs and Lagler (1964) and Pivnička (1970). Mouth length was taken as the distance from the tip of the snout to the posterior end of the maxilla. The values for morphological characters are presented as geometric means and asymmetrical standard errors. The upper limit represents the antilog of the geometric mean plus the standard error (both in log form) and the lower limit represents the antilog of the geometric mean minus the standard error (both in log form). Arithmetic means and standard errors were used for comparison with the literature. The otoliths of four specimens were aged (following Martin 1941) and confirmed that these were young-of-the-year Burbot. The conversion factor for standard length to total length was SL = 0.868 TL – 2.686 (based on 34 fish). The length-weight relationship was calculated for total length (in millimetres) and wet weight (in grams). The relative rate of growth in length and weight was calculated from the mean lengths and weights of the August and September collections (Ricker 1975). Stomach contents were identified, weighed in grams, and the data are presented as the average number of prey items per fish, percent occurrence, and percent weight for each month. A t-test was used to determine whether significant differences existed between values of morphological characters of juvenile and adult Burbot.

Results and Discussion

Although adult Burbot have been collected from the Ottawa River, both near Ottawa (McAllister and Coad 1974) and in Lac des Deux-Montagnes (Magnin and Fradette 1977), the collection for the present study represents the first young-of-the-year taken.

Collections of juvenile Burbot in eastern North America have consisted of 23 specimens from Lake Erie (Clemens 1951a), 5 specimens from the Susquehanna River system of New York State (Robins and Deubler 1955), and 8 specimens from northern Quebec (Magnin and Fradette 1977). The scarcity of specimens may be because juvenile Burbot can pass through most mesh sizes used in gillnets and trapnets. Also, they try to burrow between rocks and into cavities in the substrate during shoreline poisoning (Lawler 1963) or A.C. electrofishing (Robins and Deubler 1955). With D.C. electrofishing the juvenile Burbot swam out from concealment in cavities in the banks, among the roots of stumps and shoreline trees, and under boards and became immobilized at the anode where they were easily collected with a dipnet. Young Burbot are usually caught over rocky or gravel bottoms or rocky shorelines (Robins and Deubler 1955; Lawler 1963) but lack of this type of habitat in the collection area has resulted in part of the population using available cover in a sandy area. We did not sample possible deeper water habitats.

Table 1 records values of morphological characters of young-of-the-year Burbot for the first time. Lawler (1963) found that the values of morphometric characters of Heming Lake Burbot were directly related to the size of the fish. Ouellette and Qadri (1966) used principal component analysis to show that over 73% of the variance in morphometric measurements of Lake Char (*Salvelinus namaycush*) was explained as a general size factor. It is not surprising then that significant differences were found between values of morphometric characters available for adult Burbot and those of juvenile Burbot of the Ottawa River (Table 2). Juvenile Burbot show proportionately longer heads than adult Burbot. The young Burbot had significantly smaller proportions for most of the other characters. The significantly different values of the caudal peduncle ratio would seem to support the view that this ratio may not be suitable as a distinguishing characters for possible subspecies of Burbot (Lawler 1963; Lindsey 1956; McPhail and Lindsey 1970). Values for meristic characters were almost identical to those of Burbot of Heming Lake (Lawler 1963).

TABLE 1—Geometric means, standard errors, and log-log regressions of morphological characters of young-of-the-year Burbot (*Lota lota*) of the Ottawa River

	Mean	Lower limit	Upper limit	Log-log regression
				Morphometric characters
	(as a percentage of SL)			(on SL)
Head length	23.5	23.36	23.68	log Y = 0.885 log SL – 0.407; r = 0.9308
Preanal length	45.6	45.34	45.87	log Y = 1.058 log SL – 0.448; r = 0.9448
Predorsal length	35.6	35.38	38.80	log Y = 0.996 log SL – 0.435; r = 0.9139
Postpectoral length	33.1	32.83	33.30	log Y = 1.044 log SL – 0.558; r = 0.8852
Postpectoral ratio[a]	92.9	92.24	93.56	—
1st Dorsal fin length	6.0	5.93	6.13	log Y = 1.281 log SL – 1.751; r = 0.8327
2nd Dorsal fin length	44.3	44.03	44.49	log Y = 1.014 log SL – 0.377; r = 0.9368
Anal fin length	38.5	38.28	38.67	log Y = 1.039 log SL – 0.484; r = 0.9520
Caudal peduncle length	8.6	8.51	8.73	log Y = 1.124 log SL – 1.299; r = 0.8575
Caudal peduncle depth	6.3	6.18	6.32	log Y = 1.014 log SL – 1.226; r = 0.8613
Caudal peduncle ratio[b]	72.6	71.65	73.55	—
Maximum body depth	13.9	13.77	14.02	log Y = 1.052 log SL – 0.954; r = 0.9362
	(as a percentage of HL)			(on HL)
Eye diameter	17.5	17.31	17.74	log Y = 0.574 log HL – 0.215; r = 0.7029
Mouth length	38.6	38.16	39.01	log Y = 0.933 log HL – 0.329; r = 0.8718
1st Dorsal fin height	19.2	18.80	19.67	log Y = 0.749 log HL – 0.410; r = 0.4465
2nd Dorsal fin height	23.7	23.33	24.03	log Y = 0.760 log HL – 0.321; r = 0.7124
Anal fin height	18.1	17.71	18.40	log Y = 0.829 log HL – 0.470; r = 0.7016
Interorbital width	29.5	29.71	29.79	log Y = 1.059 log HL – 0.605; r = 0.9049
Barbel length	20.4	20.03	20.73	log Y = 0.763 log HL – 0.433; r = 0.6482
				Meristic characters
Branchiostegal rays	7.2	7.15	7.30	—
Gill rakers	8.4	8.22	8.59	—
Pyloric ceca	55.5	53.23	57.84	—

[a]Postpectoral length as a percentage of predorsal length.
[b]Caudal peduncle depth as a percentage of caudal peduncle length.

TABLE 2—Arithmetic means and standard errors of morphological characters of Burbot (*Lota lota*)

	Ottawa River, present study, N = 30	Great Lakes, Hubbs and Schultz (1941), N = 50	Lake Simcoe (Ont.), Pivnička (1970), N = 5	Heming Lake (Man.), Lawler (1963), N = 136
		Morphometric characters		
Head length	23.5 ± 0.17	22.7 ± 0.34**	21.3 ± 0.57**	—
1st Dorsal fin length	6.3 ± 0.11	7.5 ± 0.21*	6.8 ± 0.24	—
Preanal length	45.6 ± 0.26	—	52.6 ± 0.19**	—
Predorsal length	35.6 ± 0.21	38.9 ± 0.26**	39.2 ± 0.61**	—
Postpectoral length	33.1 ± 0.24	35.6 ± 0.43*	34.3 ± 0.19*	—
Postpectoral ratio[a]	93.0 ± 0.65	94.5 ± 0.40	87.6 ± 1.40**	—
Caudal peduncle ratio[b]	72.8 ± 0.97	82.0 ± 1.14**	65.8 ± 0.91**	73.5
		Meristic characters		
Gill rakers	8.4 ± 0.19	—	—	8.9 ± 0.14
Branchiostegal rays	7.2 ± 0.08	—	—	7.2
Pylorica ceca	56.8 ± 2.24	—	—	55.0

[a]Postpectoral length as a percentage of predorsal length.
[b]Caudal peduncle depth as a percentage of caudal peduncle length.
*Differs from present study at $P < 0.05$.
**Differs from present study at $P < 0.01$.

The lateral body coloration of juvenile of the Ottawa River was solid black (66%) or very dark brown with the lacey pattern associated with adult fish. The head was always solid black and both lips had either a black blotch (60%) or many black speckles. All of the fish examined had white bellies although 17% also had some light speckling. The pectoral fins had mottled bases with black rays extending almost to the edge of the fin. The pelvic fins were spotless in a few individuals (7%) but most had either a black blotch (23%) or black speckles on the outside surface of the fin. The dorsal fins were mottled with a dark margin running the length of the fins. The anal fin was white with a thin black margin that widens at the posterior end of the fin. The caudal fin was mottled with a fine clear edge and most fish (80%) had an irregular white ring in the middle area. Young Burbot have been described as being conspicuously mottled except for the pelvic fins and belly which are white (Scott and Crossman 1973) or as being purplish black with whitish-colored undersides (Lawler 1963).

Young Burbot caught in August had a mean (for 24 fish) total length of 87.3 mm and weight of 5.6 g. In September the average (for 17 fish) total length was 102.9 mm weighing an average of 7.6 g. The relative rate of increase in length and weight was 17.9% and 37.1% for one month. Clemens (1951b) reported a mean total length of 74 mm in September and 99 mm in October for a relative growth rate of 33.8% for one month. The Ottawa River fish were larger and thus the relative growth rate was somewhat less than that of the Burbot in Lake Erie.

The length-weight relationship was log WT = 2.579 log TL–4.299. Magnin and Fradette (1977) found a relationship of log WT = 2.56 log TL–3.99 for adult Burbot from Lac des Deux-Montagnes in the Ottawa River.

Table 3 summarizes the prey items eaten by young-of-the-year Burbot. Amphipods were numerically the most important item eaten in both months. Although amphipod species could not be identified from the stomach contents, benthos samples from Kettle Island showed that *Hyalella azteca*, *Gammarus fasciatus*, and *Crangonyx pseudogracilis* were readily available. In September 28.6% of the fish ate darters (*Etheostoma exile* or *E. nigrum*) which accounted for 65.7% of the weight of stomach contents. The young Burbot swallowed gastropods (*Lymnaea* sp.) with the shell intact. Clemens (1951a) found that *Gammarus* sp. and ephemeropterans were the dominant prey of the 23 juvenile Burbot examined. Robins and Deubler (1955) reported that ephemeropterans were the most important food item eaten by the five fish they captured. Bishop (1975) found that ephemeropterans and plecopterans were the dominant food of Burbot smaller than 40 mm (the number of fish examined was not stated). Nurnberger (1930) reported 1 Malacostraca, 11 insects, and 2 Miller's Thumb (*Cottus* sp.) from the stomachs of four young-of-the-year Burbot. The absence of ephemeropterans from our study is possibly due to the very low availability of ephemeropterans in benthos samples against presumably greater availability in the rocky and gravel substrates of the cited studies.

Our finding that young-of-the-year Burbot have significantly different body proportions than adult fish indicates that all size classes of Burbot need be examined from diverse populations for taxonomic

TABLE 3—Stomach contents of young-of-the-year Burbot during August and September 1979; average number of prey items per fish (top), percent occurrence (center), and percent wet weight (bottom)

Prey	August	September
No. examined	21	14
Empty stomach (%)	33.3	7.1
Total weight (g)	0.28	0.76
Food items		
Darters	0.00	0.29
	0.0	28.6
	0.0	65.7
Amphipods	5.19	5.86
	66.7	85.7
	96.7	30.0
Isopods	0.10	0.07
	9.5	7.1
	2.2	0.3
Oligochaetes	0.05	0.0
	4.8	0.0
	0.5	0.0
Dipterans	0.05	0.0
	4.4	0.0
	tr.	0.0
Odonatans	0.05	0.07
	4.8	7.1
	0.7	0.3
Gastropods	0.0	0.36
	0.0	28.6
	0.0	3.7

studies. Although young Burbot show variable color patterns, Ottawa River Burbot are the first to be described as having a white anal fin with black edge and black rays on the pectoral fins. Young-of-the-year Burbot were carnivorous, with amphipods and darters as the main prey items.

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Mortality and Dispersal of the Glaucous-winged Gulls of Southern British Columbia

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Recoveries of 1002 Glaucous-winged Gulls (*Larus glaucescens*) banded as chicks in 11 breeding colonies in British Columbia from 1963 to 1977 were analyzed. First-year (0–1 yr old) gulls died mainly between September and November; second-year gulls (1–2 yr old) showed a similar but less pronounced trend; but relatively more adults (4+ yr old) died during the late summer. Mortality rate estimates of first year gulls were between 57.9% (based on percent of bands recovered) and 59.2% (based on life table data). Glaucous-winged Gulls mostly dispersed in a southerly direction from the breeding colonies. Although individual first-year gulls dispersed farther (up to 2050 km) than older age classes, the mean dispersal distance between age classes showed little difference.

Key Words: Glaucous-winged Gull, *Larus glaucescens*, mortality, dispersal, age classes, British Columbia, aquatic birds, seasonal variations.

The dispersal pattern of small numbers of Glaucous-winged Gulls (*Larus glaucescens*) banded as chicks in British Columbia have been reported previously. Pearse (1923, 1963) found that birds of all age classes wintered in the vicinity of their nesting colony, although a few first-year gulls moved up to 2080 km. Sprot (1937) reported that most immature gulls remained within 96 km of their natal colony, but because of small samples he could provide no insight into adult dispersal.

Mortality among Glaucous-winged Gulls also has been investigated by several authors. Peak mortality of first-year Glaucous-winged Gulls banded 1938–1940 occurred in January (Woodbury and Knight 1951). Van Tets (1968) showed that mortality among first-year birds occurred mainly from November to February. Vermeer (1963) found that 86.8% of 68 adult Glaucous-winged Gulls survived from one breeding season until the next one.

The purpose of this paper is to document the dispersal and seasonal mortality of a large sample of Glaucous-winged Gulls banded as chicks in southern British Columbia since 1963.

Methods

We analyzed 1002 recoveries of gulls banded as chicks in 11 colonies between 1963 and 1977 (Figure 1). Most Glaucous-winged Gull chicks from breeding colonies around Vancouver Island fledge in August (Vermeer 1963; personal observation). Those chicks that died before leaving the island were excluded from the analysis because we are here discussing mortality during and after dispersal. All young birds that dispersed from the natal colony were included in the analysis. We considered a given gull to be 1 yr old when 365 d had passed since its date of banding as a chick. Thus a first-year bird is between 0 and 1 yr old. We also assumed that a bird died on the day it was recovered.

Results and Discussion

The greatest number of first-year gulls were recovered from September through November, rather than during the winter months (Figure 2). A similar but smaller peak of recoveries occurred from October to December among second-year birds (Figure 2). This suggests that whatever causes mortality among first-year birds in the autumn apparently still has an effect on second-year birds. It may be, in part, a result of inexperience in finding food (Verbeek 1977a, b; Searcy 1978). One of us (RWB) has seen one first-year Glaucous-winged Gull begging and being fed by an adult as late as January. Second-year birds, although relatively more experienced than first-year birds, may be subject to interference competition from recently fledged chicks or adults (Searcy 1978).

Recoveries of birds 2–3 and 3–4 yr old occurred in about equal numbers throughout the year (Figure 2). Recoveries of adults (4 yr and older) were most numerous in August through October, and this may be a result of the breeding effort itself, since no similar trend was seen among 2- and 3-yr-old gulls (Figure 2). Similar seasonal mortality trends for immatures and adults were found by Spaans (1971) for the Herring Gull (*L. argentatus*) and by Coulter (1975) for the Western Gull (*L. occidentalis*). In one population of Western Gulls studied by Coulter (1975), mortality of immature and adult gulls occurred largely from October to March.

Careful estimates on four islands (Cleland, Christie,

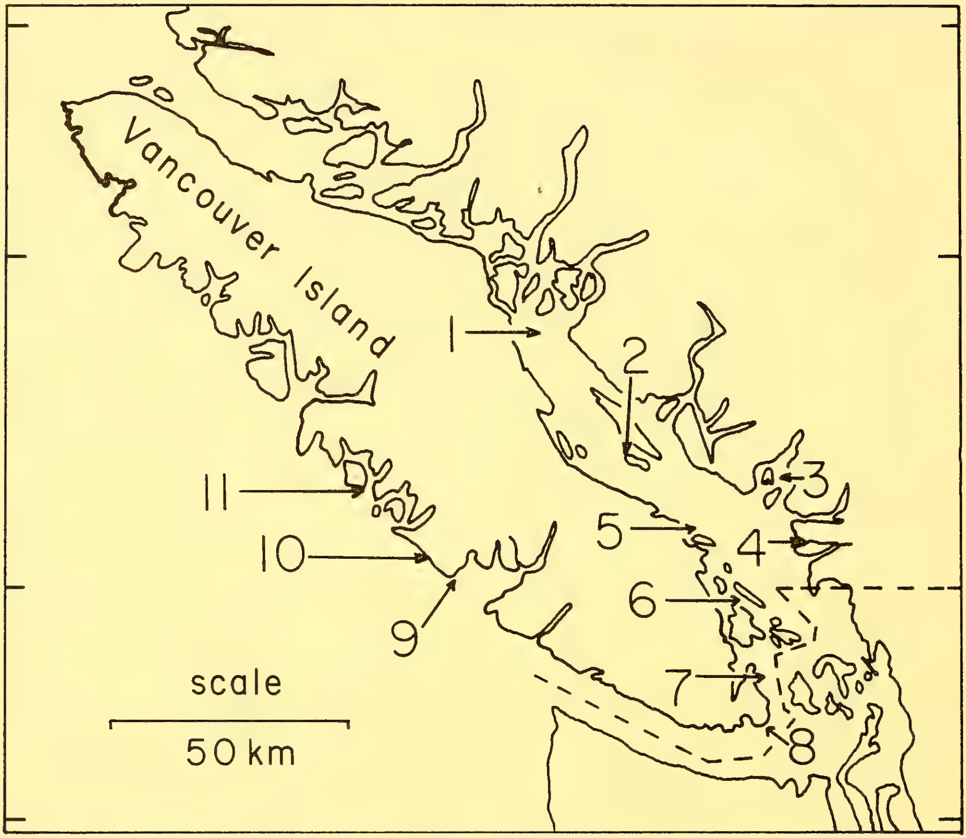

FIGURE 1. Location of 11 Glaucous-winged Gull breeding colonies and banding locations discussed in this study: 1—Mitlenatch Island, 2—Lasqueti Island, 3—Pam, Christie, and Passage Islands (Horseshoe Bay), 4—Westham Island, 5—Snake Island, 6—Ballingal Islet, 7—Mandarte Island, 8—Chain Islets, 9—Ucluelet, 10—Long Beach, 11—Southeast Flores Island, all in British Columbia.

Mandarte, and Mitlenatch) indicate that the breeding population of Glaucous-winged Gulls has increased about 3.5 times between 1928 and 1974 (data in Drent and Guiguet 1961; Campbell 1975, 1976). Presumably most of this increase has occurred in the last 10–30 yr as shown in other species of gulls in the northern hemisphere (Kadlec and Drury 1968; Verbeek 1977c). We suggest that the dramatic forward shift in mortality among first-year Glaucous-winged Gulls from December–February (birds banded in 1938–1940, Woodbury and Knight 1951) to September–November (birds banded in 1963–1977, this study) may be the result of this increase in the population. In an environment saturated with gulls, competition for food with adults may result in many young dying shortly after dispersal from the colonies rather than later in the winter.

Figure 3 shows the numbers of birds found belonging to the various age classes. The last banding year included in this study was 1977 and the last band recovery year was 1978. All banded gulls alive after 1978 are, therefore, older than 1 yr of age. To determine accurately the age-specific mortality rate of all Glaucous-winged Gull age classes we should wait until all of the banded gulls have died; however, a few points can now be stated. Many Glaucous-winged Gulls appear to die in their first year (Figures 2, 3). Of 1002 banded recoveries, 581 were from first-year gulls, giving a mortality rate estimate of 57.9%. The remaining living gulls that will die after 1978 will lower but not greatly alter this percentage. If a vertical life table is constructed based on the 1002 band recoveries (keeping in mind that a bias against gulls 2 yr and older is present), a first-year mortality rate of 59.2% is evident. Vermeer (1963) estimated that first-year mortality in Glaucous-winged Gulls would be about 70%,

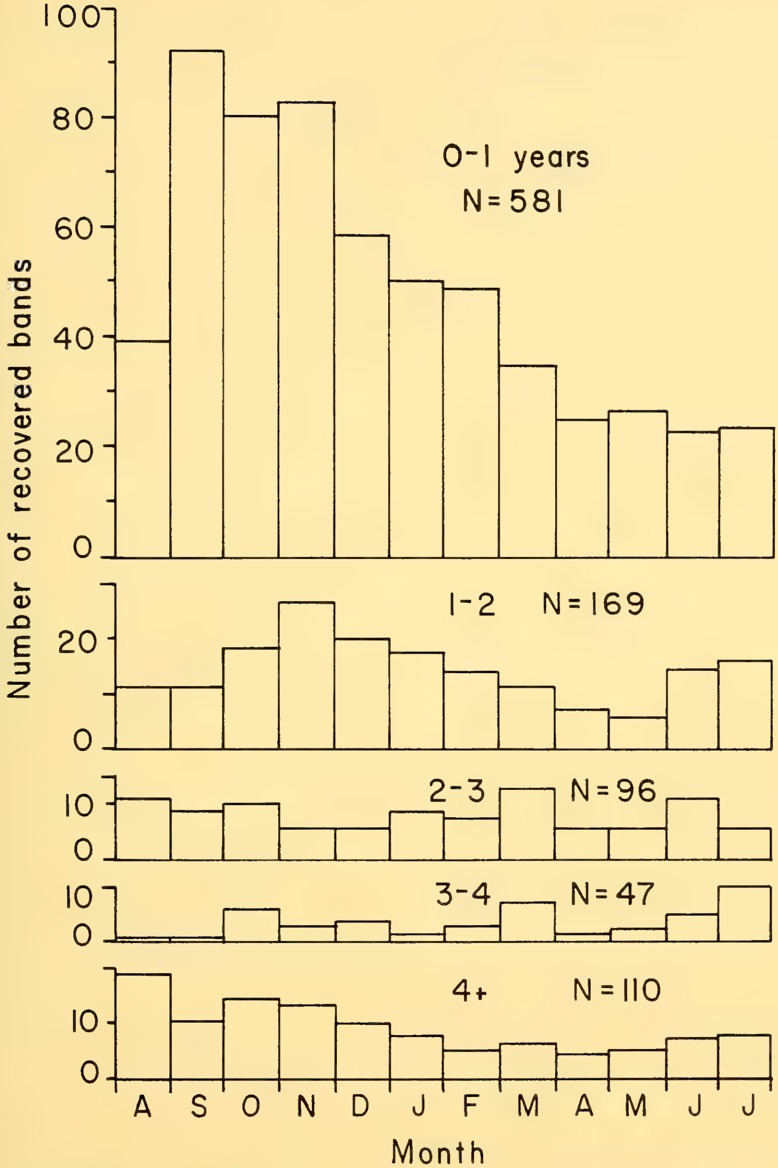

FIGURE 2. Number of bands recovered per month and age class from Glaucous-winged Gulls in British Columbia.

but Pearse (1963) found only 57% of 100 band recoveries of Glaucous-winged Gulls were in their first year, which is much closer to our figures.

In five colonies for which sufficient numbers of banded birds were recovered, the majority were found southward from the colonies (Table 1). The chance of recovering a banded gull depends partly on the number of people living in the area. One would thus expect fewer Glaucous-winged Gull recoveries northward from the colonies because relatively few people live there. Although two islands where Glaucous-winged Gulls were banded (Chain and Mandarte) have large human populations to the north (Victoria and Vancouver, British Columbia, respectively), most recoveries from those islands nevertheless occurred to the south (Table 1). In general then, Glaucous-winged

TABLE 1—Number and percent of all band recoveries found to the north and south of the banding locations

	North		South	
Banding location (#)[1]	N	(%)	N	(%)
Mitlenatch Island (1)	58	(14.4)	345	(85.6)
Horseshoe Bay (3)	1	(1.3)	74	(98.7)
Mandarte Island (7)	72	(38.0)	120	(62.0)
Chain Islets (8)	39	(24.8)	118	(75.2)
Flores Island (11)	37	(29.1)	90	(70.9)

[1]See Figure 1.

Gulls appear to disperse southward in autumn. Coulter (1975) noticed the same trend in Western Gulls.

With the exception of one Glaucous-winged Gull found at St. Paul, Alberta (Merilees 1961), all gulls were recovered along the west coast of North America. The farthest distance reached by recently fledged individuals shows a regular progression from August to November (Table 2). In crude terms this indicates a rate of dispersal of about 350 km/mo. Vermeer (1963) reported a juvenile Glaucous-winged Gull that was seen on Mandarte Island on 30 August and recovered on 8 November in San Francisco, California. Table 2 clearly shows two areas of concentration of recoveries: 0–550 km (which includes major human population centers such as Vancouver, British Columbia; Seattle and Tacoma, Washington; and Portland and Eugene, Oregon) and 1150–1450 km (centered around San Fransisco Bay, California). Relatively few birds

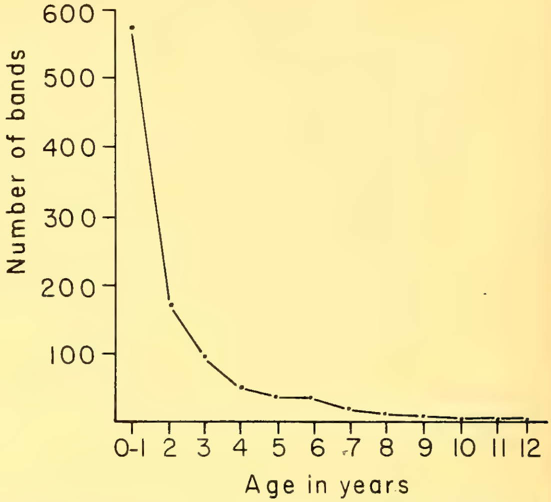

FIGURE 3. Number of bands recovered from the various age classes of Glaucous-winged Gulls in British Columbia.

TABLE 2—Number of recoveries of first-year birds by month and distance from the banding location

	No. of recoveries in month (August to July)												
Distance (km)	A	S	O	N	D	J	F	M	A	M	J	J	Total
0–50	34	51	35	27	15	14	10	16	8	11	9	6	236
51–100	1	11	14	16	7	8	12	5	3	1	3	5	86
101–150	1	8	4	5	8	5	4	4	2	1	—	5	47
151–200	—	9	11	13	11	4	5	1	1	2	2	1	60
201–250	2	5	3	6	4	1	3	—	2	1	—	1	28
251–350	1	5	9	5	4	4	2	5	1	1	1	1	39
351–450	—	—	2	2	3	2	—	—	1	1	1	—	12
451–550	—	3	1	2	2	3	1	—	—	2	—	1	15
551–650	—	—	—	2	1	1	1	—	—	—	2	2	9
651–750	—	1	—	—	—	—	—	—	—	1	—	—	2
751–850	—	—	1	—	—	—	—	—	1	—	1	—	3
851–950	—	—	—	1	—	—	—	—	1	2	—	—	4
951–1050	—	—	—	—	—	—	—	—	—	—	—	—	0
1051–1150	—	—	—	1	—	1	1	—	—	—	—	—	3
1151–1250	—	—	—	1	—	—	2	3	1	1	1	1	10
1251–1350	—	—	—	1	1	6	3	—	1	1	—	—	13
1351–1450	—	—	—	1	2	1	3	1	1	1	1	—	11
1451–1550	—	—	—	—	—	—	—	—	—	—	—	—	0
1551–1650	—	—	—	—	—	—	—	—	—	—	1	—	1
1651–1750	—	—	—	—	—	—	—	—	1	—	—	—	1
1751–1850	—	—	—	—	—	—	—	—	—	—	—	—	0
1851–1950	—	—	—	—	—	—	—	—	—	—	—	—	0
1951–2050	—	—	—	—	—	—	1	—	—	—	—	—	1

TABLE 3—Number of recoveries of fourth-year birds and older by month and distance from the banding location

	No. of recoveries in month (August to July)												
Distance (km)	A	S	O	N	D	J	F	M	A	M	J	J	Total
0–50	9	3	3	4	6	3	3	2	5	2	3	4	47
51–100	4	—	2	—	—	—	—	—	—	1	—	—	7
101–150	2	1	1	—	—	—	—	—	—	1	—	—	5
151–200	1	—	2	3	—	4	—	1	—	—	1	2	14
201–250	1	1	1	—	—	—	—	1	—	1	1	1	7
251–350	—	2	—	—	—	1	2	—	—	—	—	2	7
351–450	—	1	1	1	1	—	—	—	—	—	—	1	5
451–550	—	1	1	—	—	—	—	—	—	—	—	—	2
551–650	1	1	—	3	1	—	—	—	—	—	—	—	6
651–750	—	1	—	—	—	—	—	—	—	—	—	—	1
751–1150	—	—	—	—	—	—	—	—	—	—	—	—	0
1151–1250	—	—	—	—	—	—	—	1	—	—	—	—	1
1251–1350	—	—	—	—	1	—	—	—	—	—	—	—	1
1351–1450	—	—	1	1	1	2	—	1	—	—	—	—	6

were recovered on the sparsely populated coast between 550 and 1150 km (southern Oregon and northern California). The Glaucous-winged Gull feeds extensively on garbage (personal observation). In California it is typically associated with dumps and less often with bayside and outer coast locations (Cogswell 1977). The Western Gull, on the other hand, is much more restricted to the marine environment (Cogswell 1977). In contrast to our findings for Glaucous-winged Gulls, Coulter (1975) reported many Western Gull recoveries from southern Oregon and northern California coasts; i.e., there are people there to find banded gulls. Thus, the observed difference between the two species might reflect a difference in choice of feeding substrate. The adult Glaucous-winged Gulls showed a similar recovery pattern (Table 3) to that shown by first-year birds (Table 2), with no adults recovered between 750 and 1150 km.

Ian McGregor read the band numbers of living gulls through a telescope at many locations along the British Columbia, Washington, and Oregon coasts each year from 1967 to 1974. These band numbers were not included in the 1002 recoveries that we analyzed. Of 379 gulls of all ages that he identified, 35 were seen in 2 or more years. Among these 35 gulls, 9 were adult birds in at least one sighting; 31 were within 50 km of the previous sighting(s), 3 between 51 and 100 km, and 1 between 100 and 150 km of the earlier sighting. The traditional use of wintering sites by individual Glaucous-winged Gulls was reported by Vermeer (1963).

Several authors have shown that young Herring Gulls disperse more widely than adults, while others have shown that this does not hold for all populations (see Spaans 1971 for references). Woodbury and Knight (1951) reported that first-year Glaucous-winged Gulls travelled farther than adult birds, although in our data 11 age classes showed similar dispersal patterns (Table 4). Gabrielson and Jewett (1970) said that first-year Glaucous-winged Gulls

TABLE 4—Proportion of each age class and distance from the banding location of 1002 recovered bands

	No. and percent recoveries in age class (yr)				
Distance (km)	N (%)	N (%)	N (%)	N (%)	N (%)
0–50	236 (41)	60 (39)	39 (41)	19 (40)	47 (43)
51–100	86 (15)	25 (15)	12 (13)	10 (21)	7 (7)
101–150	47 (8)	17 (10)	8 (8)	6 (13)	5 (5)
151–200	60 (10)	21 (12)	13 (14)	4 (9)	14 (13)
201–250	28 (5)	7 (4)	6 (6)	3 (6)	7 (6)
251–650	75 (13)	21 (12)	12 (13)	1 (2)	20 (19)
651–1050	9 (2)	5 (3)	3 (3)	1 (2)	1 (1)
1051–1450	37 (6)	12 (7)	3 (3)	3 (6)	8 (7)
1451–2050	3 (1)	1 (1)	0 (0)	0 (0)	0 (0)

appeared on the Oregon coast before the adults and that both age classes were present in winter. Baltz and Morejohn (1977) reported that from November to about May, Glaucous-winged Gulls were common but not abundant on Monterey Bay, California, but adults were seldom seen.

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We gratefully acknowledge the time and effort of the many people who have banded Glaucous-winged Gulls on the coast of British Columbia. Most prominent among them were R. W. Campbell and M. G. Shepard, who also loaned us their band recovery data. I. McGregor showed untiring enthusiasm in identifying gulls by reading their bands through his telescope. We appreciate helpful comments received from C. S. Houston. The study was supported by the National Sciences and Engineering Research Council of Canada (A0239).

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Notes

Marine Algae New or Rare to Northern British Columbia

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During July 1979 marine intertidal algae were collected on Langara Island, the northernmost of the Queen Charlotte Islands. Of the approximately 150 species collected, 28 were formerly unknown from northern British Columbia. Of these, *Ulvella setchellii, Audouinella concrescens, A. daviesii, A. membranacea, A. variabile* (Drew) Garbary *comb. nov.*, and *Bonnemaisonia geniculata* are new to British Columbia. Many species known from both Alaska and southern British Columbia are reported for the first time from the intervening region, and 21 species were found to have new northern distribution limits. Six species recorded previously for the mainland (and adjacent islands) are new records for the Queen Charlotte Islands.

Key Words: Acrochaetiaceae, *Audouinella, Bonnemaisonia geniculata,* marine algae, northern British Columbia, Queen Charlotte Islands.

In comparison with the areas to the immediate north and south, the marine algae of northern British Columbia (region between northern tip of Vancouver Island and Alaska) remain poorly known. Hawkes et al. (1978) summarized early literature, and reported many new records based on their own and others' collections. Despite this work, at least 70 species known from the contiguous coastal areas are yet to be reported from northern British Columbia. In addition, the reported flora for the region contains over 100 species fewer than that of Alaska (Lindstrom 1977), and less than half that recorded for the area of southern British Columbia and northern Washington (Scagel 1966; Widdowson 1973, 1974). Although there may be biogeographic and hydrographic factors that account for this apparent discrepancy, much of it can be attributed to paucity of collecting in the area. In this paper we report the results of a collecting expedition to Langara Island, the northernmost of the Queen Charlotte Islands.

Study Area and Materials and Methods

Langara Island (Figure 1) was visited by two of us (D. G. and L. G.) July 16–30, 1979. The coastline of this island is highly dissected with numerous reefs and headlands. The west, north, and east coasts are very exposed, and moderate protection is found only on the south coast in the waters between Langara and Graham Islands. We made collections in four areas of the island (see arrows in Figure 1): (1) Langara Point, (2) Lord Bight, (3) west of McPherson Point, and (4) Fury Bay. Only Fury Bay was previously collected (Hawkes et al. 1978). In addition, in the area of Langara Point, several shores were visited: (a) Langara Point, below lighthouse, (b) cove to west of Langara Point, (c) beach along disused trail to lighthouse, and (d) cove at boat dock to east of Langara Point.

Voucher specimens for all collections are deposited in the phycological collection of the University of British Columbia Herbarium (UBC).

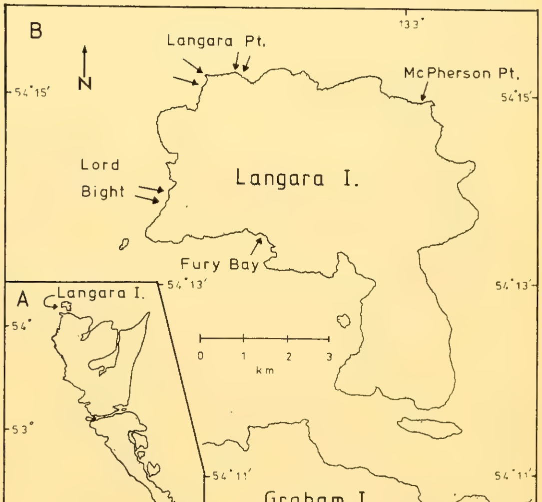

FIGURE 1. A, Generalized map of Queen Charlotte Islands. B, detailed map of Langara Island showing collecting sites (arrows).

Results and Discussion

During the 2-wk collecting period approximately 150 species of marine intertidal algae were collected on Langara Island. Because most of these taxa were reported previously for the island, or represent minor range extensions from adjacent Graham Island (Hawkes et al. 1978), these are not listed here. Many of the collections, however, are of biogeographic and floristic interest in that they represent extensions of previously recorded distributions. Extensions are categorized into four types that are not mutually exclusive and are summarized in Table 1.

TABLE 1—New distribution records for marine algae in northern British Columbia: 1—algae new to British Columbia; 2—algae new to northern British Columbia; 3—algae with new northern distribution limits; 4—algae new to the Queen Charlotte Islands. Data on previous distributions compiled from Abbott and Hollenberg (1976), Drew (1928), Garbary (unpublished data), Hawkes et al. (1978), Lindstrom (1977), Phinney (1977) and Scagel (1957)

	New distributions				
Taxon	1	2	3	4	Previous distributions
Chlorophyta					
Bryopsis plumosa			*		Moresby Island to California
Cladophora microcladioides				*	northern B.C. to Mexico
C. stimpsonii		*	*	*	southern B.C. to California
Rhizoclonium riparium		*		*	Alaska, southern B.C. to Chile
Ulothrix laetevirens		*		*	Alaska to California
Ulvella setchellii	*	*	*	*	Washington to California
Urospora mirabilis				*	Alaska to California
Phaeophyta					
Colpomenia bullosa		*		*	Alaska to California
Laminaria emphemera		*		*	Alaska to California
Punctaria expansa		*	*	*	southern B.C., Washington
Ralfsia pacifica		*		*	Alaska to Mexico
Rhodophyta					
Ahnfeltia plicata		*		*	Alaska, southern B.C. to Mexico
Antithamnionella pacifica var. *uncinata*				*	Alaska to Mexico
Audouinella amphiroae		*	*	*	southern B.C. to Mexico
A. concrescens	*	*	*	*	California, southern B.C.
A. daviesii	*	*	*	*	Washington to California
A. densa		*	*	*	southern B.C. to California
A. membranacea	*	*	*	*	Washington, southern B.C.
A. plumosa		*	*	*	southern B.C. to California
A. porphyrae		*	*	*	southern B.C. to California
A. variabile	*	*	*	*	Washington to California
Bonnemaisonia geniculata	*	*	*	*	California
Botryoglossum farlowianum		*		*	Alaska, southern B.C. to Mexico
Ceramium rubrum		*		*	Alaska, southern B.C., Washington
C. washingtoniense			*	*	northern B.C. to Oregon
Cryptonemia obovata		*		*	Alaska, southern B.C. to Mexico
Erythrotrichia carnea		*		*	Alaska to Mexico
E. pulvinata		*	*	*	southern B.C. to Mexico
Farlowia compressa		*		*	Alaska, southern B.C. to Mexico
F. mollis				*	Alaska to California
Fryeela gardneri			*		Moresby I. to Mexico
Grateloupia pinnata		*		*	Alaska, southern B.C., Washington
Hildenbrandia prototypus				*	Alaska to Panama
Hymenena kylinii		*	*	*	southern B.C. to California
Pikea californica		*	*	*	southern B.C. to California
Porphyra kanakaensis		*	*	*	southern B.C. to California
P. schizophylla				*	Alaska to California
Prionitis filiformis			*		Moresby I., southern B.C. to Mexico
P. linearis				*	northern B.C. to Mexico
Ptilothamniopsis lejolisea			*		northern B.C. to Mexico

Six species were found that were previously unreported for British Columbia including one green and five red algae: *Ulvella setchellii, Audouinella concrescens, A. daviesii. A. membranacea, Audouinella variabile* (Drew) Garbary *comb. nov.* (see Appendix I), and *Bonnemaisonia geniculata.* Five of these (i.e., the *Audouinella* species and *U. setchelli*) are minor range extensions from northern Washington (Drew 1928; Abbott and Hollenberg 1976). In addition, three of the *Audouinella* species (except *A. daviesii*) have subsequently been found in Barkley Sound (Garbary, unpublished data).

Bonnemaisonia geniculata is the most important new record in that this species was considered endemic to California (Abbott and Hollenberg 1976; Shevlin and Polanshek 1978). In 1976 tetrasporic plants that corresponded to the tetrasporophytic stage of *B. geniculata* were collected in the Queen Charlotte Islands. In the present study a single fertile female gametophyte was collected on Langara Island where it was growing epiphytically in the lower intertidal region. The presence of both gametophytic and tetrasporophytic phases of *B. geniculata* in northern British Columbia indicates that this species has a normal life history in this area, and that *B. geniculata* has a much wider distribution than is presently known.

Twenty-eight new records for marine algae were found for northern British Columbia (Table 1). Of these, 12 species have been reported from adjacent coastal areas (Alaska and southern British Columbia) and form part of a continuous distribution from Alaska south; however, over 50 additional taxa known from both Alaska and southern British Columbia have not yet been found in the intervening region.

The remaining 16 new records for northern British Columbia are extensions of the northern distribution limits of taxa found only to the south. Thus based on these and earlier collections, Langara Island and vicinity (stations 24–26 in Hawkes et al. 1978) is the known northern distribution limit for over 60 species. Because Alaska is only 50 km from Langara Island it is unlikely that this apparent discontinuity is real, and that many of these taxa will be found in Alaska. The work of Lindstrom and Scagel (1979) is a case in point.

A comparison of the algae known for the mainland (and adjacent islands) in northern British Columbia, and the Queen Charlotte Islands shows that there are about 90 species found only in the latter whereas there are only 20 taxa that have not been reported from the Queen Charlottes. The present study located six such taxa (Table 1) that were previously known only for the mainland (and nearshore islands). More extensive collecting is required, however, to verify whether this apparent local endemism is a real or artificial phenomenon.

Acknowledgments

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APPENDIX I. A new combination in *Audouinella*

Audouinella variabile (Drew) Garbary *comb. nov.*
Basionym: *Rhodochorton variabile* Drew (1928), University of California Publications in Botany 14: 174.

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Feeding of the Arctic Blue Larva and Butterfly

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Day, Robin T. and Bernard S. Jackson. 1980. Feeding of the Arctic Blue larva and butterfly. Canadian Field-Naturalist 94(3): 324.

A larva of the Arctic Blue, *Agriades aquilo*, butterfly was collected and reared for the first time on flowers of the arctic-alpine plant *Diapensia lapponica*. Descriptions of the larva and egg are given and some adult nectar sources are listed.

Key Words: *Agriades aquilo*, Arctic Blue Butterfly, larva, egg, nectar source, *Diapensia lapponica*, Newfoundland.

The Arctic Blue, *Agriades aquilo*, is widespread in Canada ranging from Manitoba to Labrador and north to Ellesmere Island (Klots 1951).

At the Gannet colonies of Cape St. Mary's, Newfoundland (46°49′N, 54°12′W), on 19 May 1979, near the sea cliffs, a small caterpillar was found on a flowering plant of *Diapensia lapponica*. The *Diapensia* showed no signs of having been fed upon except for some small holes in unopened flower buds. Similar small holes had been noticed at a distant site, the Hawke Hills (47°20′N, 53°05′W), the previous year (Day 1978). Both plant and larva were collected to rear the adult for identification. The plant was placed with the caterpillar in a glass jar with a sprinkling of water to maintain humid conditions and was kept at approximately 25°C. The larva consumed only flowers and by 28 May had begun pupation, exhibiting a translucent chrysalis, which by 30 May had taken on a brown color. On 12 June an Arctic Blue, *Agriades aquilo*, emerged. The advanced development of the larva by 19 May in the cool foggy habitat of Cape St. Mary's suggests that the Arctic Blue overwinters in this stage of metamorphosis.

We have failed to find a published photograph of the larvae of this species and what follows is possibly the first written specific description, drawn from personal observations. The larva was small, short and thick, approximately 1.2 mm long and 0.6 mm broad, pale green with liberal reddish markings over the dorsal surface. This very likely serves as camouflage on the green and anthocyanin-red tinged vegetation. The body had many fine, long, silky setae projecting from its surface. Unlike many lepidopterous larvae, the Arctic Blue caterpillar remained stationary when handled at 25°C ambient temperature.

Diapensia was not previously known to have any predators, large or small (Day 1978) but Klots (1951) quotes T. N. Freeman as saying he observed the Arctic Blue ovipositing on *Diapensia* at Baffin Island. We could obtain no other information concerning this observation. Thus, our information is believed to be the first confirmed rearing of the Arctic Blue on the native food plant *Diapensia lapponica*. In Europe *Astragalus alpinus* (Milk-Vetch) is another host plant (Higgins and Riley 1971); this plant also grows in western Newfoundland.

An Arctic Blue was observed ovipositing a single egg 0.5 cm distant from a shoot tip of *Empetrum nigrum* (Black Crowberry) located near the town of Flatrock, Avalon Peninsula, Newfoundland (47°42′N, 52°42′W) on 4 July 1976. The egg was placed at the base of a leaf and was a white-cream color with yellow yolk, circular in dorsal view with a diameter of 0.75 mm, a symmetric oval viewed laterally 0.25 mm in depth and with a reticulate chorion except at the smooth, apical, circular micropyle. Adults at this time were feeding from flowers of *Ledum groenlandicum* (Labrador Tea), *Vaccinium vitis-idaea* (Mountain Cranberry), *Cornus suecica* (Swedish Crackerberry), and *Linnaea borealis* (Twinflower).

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Status of the West Virginia White Butterfly on Manitoulin Island

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Morton, J. K. and R. R. Tasker. 1980. Status of the West Virginia White butterfly on Manitoulin Island. Canadian Field-Naturalist 94(3): 325–327.

The West Virginia White (*Artogeia virginiensis*), the only butterfly on Ontario's Endangered Species List, was discovered in a number of localities on Manitoulin Island, Ontario. We regard it as locally common in suitable hardwood habitats where the food plants (*Dentaria diphylla* and *D. laciniata*) of the larvae grow. We have reviewed and mapped its present and past distribution in Canada. Protection of the butterfly habitat on Manitoulin Island is important to ensure its continued survival.

Key Words: West Virginia White, *Artogeia virginiensis*, endangered species, Manitoulin District, *Dentaria*, ecological distribution.

The West Virginia White (*Artogeia virginiensis*) is the only butterfly on Ontario's list of endangered species. The insect, which has only recently clearly emerged as a species distinct from the Mustard White (*Artogeia napi oleracea* Harris), has an interesting history in the province. According to Riotte (1967) and Holmes (1975) it was first recorded in Ontario in 1868 and 1872 by Edwards who received specimens from William Saunders in London. Bethune (1894, 1896) listed it as *Pieris napi* form *virginiensis* from Fort William, Hamilton, and Orillia. Historical specimens still preserved in the collection of the Royal Ontario Museum include two from London, Ontario from the H. S. Saunders collection (24 April 1900), two from Etobicoke, Ontario from the Dunlop collection (1 and 5 May 1955), as well as one from St. Hilaire, Quebec (24 May 1900). Warren (1963) reports the existence of a specimen in the collection of the British Museum from "Grand La Cloche Island" presumably Great Cloche Island, Manitoulin District, Ontario. Ontario specimens in the Canadian National collection include 1 from Hamilton (May 1881) and 4 from the Halton County Forest (dates not specified); Quebec specimens include 9 from Montreal, (1898 and 2 and 17 May 1903) and 11 from Ile Perrot (12 April 1945 and 26 May 1950).

In 1965 this species was thought to be extinct in Ontario, all the remembered sites having been destroyed by development. Similarly, the St. Hilaire colony was said to be extinct and the staff at the Lyman Museum in Montreal had not seen a specimen in years.

Intrigued by this story, A. M. Holmes (1975) studied topographic maps of the Hamilton area, explored the large wooded area around Campbellville, Ontario and rediscovered the insect there on 9 May 1965. Specimens from this area have subsequently been placed in the collections of the Royal Ontario Museum, University of Guelph, and the National Museum of Canada.

In 1969 the Toronto Entomological Association, concerned about the future of *A. virginiensis* in Ontario and of the Currie Tract where it occurred, began negotiations with the Ontario Ministry of Natural Resources. These culminated in the insect being placed on Ontario's endangered species list on 26 January 1977 (Ontario regulation 33-77), thereby providing the essential habitat protection that is included in the related legislation.

The similarity between the Halton County Forest, where the West Virginia White had been rediscovered, and areas on Manitoulin Island impressed one of us (R.R.T.). Because of this and the existence of the record from nearby Great Cloche Island, where no suitable habitat now appears to occur, a systematic search was begun in the Manitoulin area for this butterfly and its food plants, the toothworts (*Dentaria diphylla* and *D. laciniata*). Directed to a woodlot near Ice Lake that contained both species of toothwort, R.R.T. found a few specimens of *A. virginiensis* on 20 May 1973. Representative specimens were placed in the collection of the Royal Ontario Museum after confirmation of their identity by J.C.E. Riotte (Tasker 1974). Subsequently, two further colonies were discovered in other locations on the island.

During the past few years J.K.M. has had the opportunity to visit many areas of deciduous woodland on Manitoulin Island during the course of a study of the flora (Morton 1977) and Lepidoptera of the region. Consequently, our knowledge of the range of this butterfly on the island has been extended considerably and we are convinced that it is quite a common, if local, insect over a large area of the central part of the island. Figure 1 shows all the stations where we have seen the butterfly during the past few years, and also known sites for the food plants (*Den-*

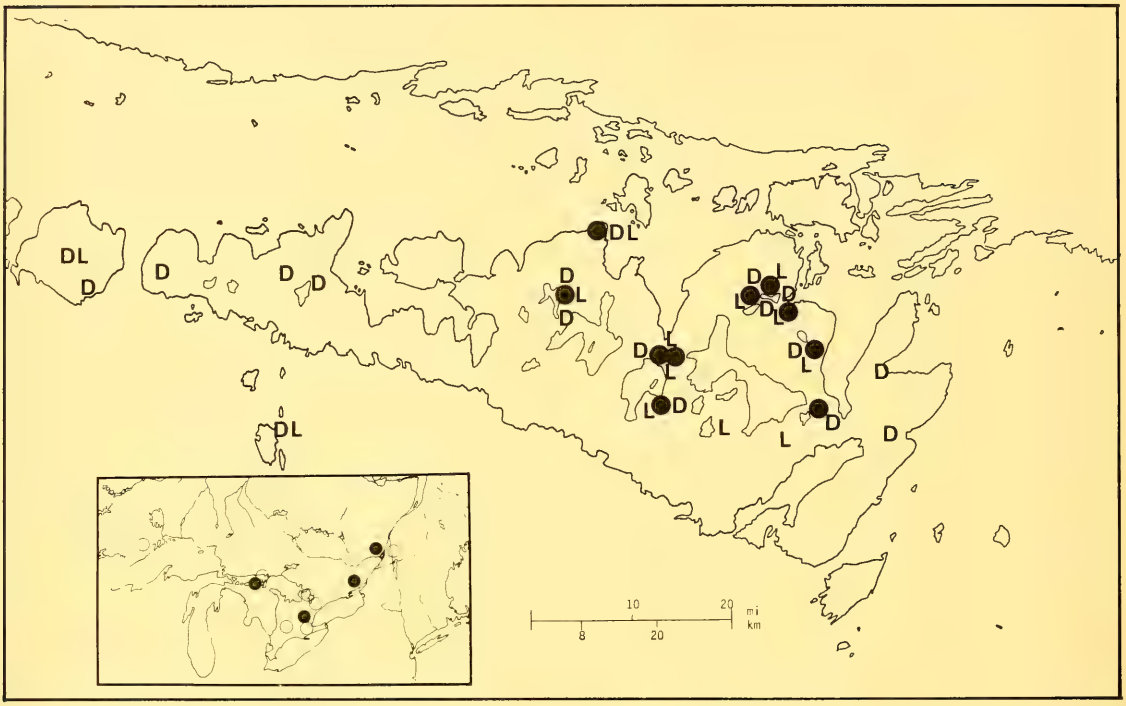

FIGURE 1. Map of Manitoulin Island: closed circles are sites for *Artogeia virginiensis;* D and L are sites for the food plants *Dentaria diphylla* and *D. laciniata*, respectively. The inset map shows the present known range of the West Virginia White in Ontario and Quebec (solid circles = existing stations; open circles = sites where it is thought to be extinct).

taria). In most localities several individuals of the insect were seen and in some it was abundant.

In 1978 we heard of reports of an additional Ontario colony in Frontenac County, but we are unable to confirm these reports. The insert map of the Great Lakes Region (Figure 1) shows all known sites where the butterfly has been recorded in Ontario and Quebec.

The wide separation of the three known populations of the butterfly in Ontario (Frontenac County, Halton County, and Manitoulin Island) raises the question of how this pattern of distribution evolved. There can be little doubt that until recently the West Virginia White had a wider distribution in Ontario and that destruction of its habitat has led to a contraction of its range. It is unlikely, however, that the range was continuous from southern Ontario to Manitoulin Island. The Manitoulin populations almost certainly have their affinities with those in the nearby upper peninsula of Michigan where the butterfly is of wide occurrence: "Practically any large wooded site in the northern Lower Peninsula and the Upper Peninsula . . . will yield populations . . ." (Wagner 1978).

The food plants of larvae of the West Virginia White are reported to be toothworts (*Dentaria* sp.) (Klots 1951; Ehrlich and Ehrlich 1961). On Manitoulin Island these plants were observed in all the stations where the butterfly was encountered (see Figure 1). The distribution of the butterfly, however, coincides much more closely with that of *Dentaria laciniata*, rather than with that of the commoner *D. diphylla* which is usually cited as the food plant. Furthermore, one of us (J.K.M.) has, on two occasions, observed female butterflies ovipositing on *D. laciniata*. The habitat requirements of these two species of toothwort on Manitoulin Island are quite different. *Dentaria laciniata* favors the well-drained, humus-rich soils of the deciduous woods, whereas *D. diphylla* tends to grow in the cold wet bottomland of the woods, where the shade is more intense and the habitat is colder. When we have seen this butterfly on the wing, it has usually been in the former type of habitat where the sun penetrates the woodland in May before the leaves on the trees have fully expanded.

The West Virginia White is single brooded on Manitoulin Island whereas the similar Mustard White has a second summer brood. There is little difficulty in distinguishing the two insects, however, because the

spring brood of the Mustard White differs markedly from that of the West Virginia White. The summer brood, which resembles the West Virginia White brood more closely except for size, flies long after adults of the latter species have disappeared. The West Virginia White, on Manitoulin Island, emerges about the end of the first week of May, usually at least a week before the Mustard White. It flies freely in mild sunny weather during May and early June.

The continued survival of this butterfly on Manitoulin Island depends on protecting the rich deciduous woodland where the food plants are common. Moderate disturbance of the woodland in the form of selective cutting, or the felling of limited sectors appears to favor the butterfly by providing sunny openings and glades with luxurious regrowth and a wealth of spring flowers. The food plants soon colonize and spread in these areas and the butterfly can often be found in abundance in them. It would appear that it is important to prevent over-exploitation and clear-felling of these woods if the butterfly is to survive. It is also most important to prevent grazing of the woods by cattle. A common practice on the island is to allow cattle to wander in woodlots. With grazing, the rich spring ground-flora, including the toothworts, is rapidly destroyed and the habitat becomes unsuitable for the butterfly. Several of the sites for the West Virginia White on Manitoulin Island are already threatened. The Ice Lake woodlot, where the species was first discovered on the island, though adjacent to a larger, better-preserved area of forest, is itself threatened by extensive cutting for fuel and possible clearing for agriculture. Another site is being severely damaged by a cottage development, and what is probably the largest colony occurs in a forest partially felled for lumber and under threat of being clear-felled. Hence we believe that efforts should be made to protect several of the woodlots where the larger colonies occur. Not only would this ensure the survival of the butterfly, but these sites are also the home of many interesting and rare plants, and of a wealth of other Lepidoptera, many of which are not found elsewhere in the Manitoulin region.

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Turkey Vulture Predation of Ruffed Grouse Chick

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An apparent instance of a Turkey Vulture (*Cathartes aura*) preying on wild prey, a Ruffed Grouse (*Bonasa umbellus*) chick, in a natural situation was observed.

Key Words: Turkey Vulture, *Cathartes aura*, Ruffed Grouse, *Bonasa umbellus*, predation.

The following incident took place at Warrior Mountain Wildlife Management Area, Allegany County, Maryland. At about 14:00 on 9 June 1978, K. Titus observed a Turkey Vulture (*Cathartes aura*)

standing in a field. A small bird held in the vulture's beak was observed moving, indicating that the prey was alive. The prey appeared to be a Ruffed Grouse (*Bonasa umbellus*) chick about 1 wk old. The vulture looked towards Titus and then slowly flew off with the bird in its beak. Inspection of the spot from where the vulture flew revealed eight Ruffed Grouse chicks crouched motionless in the grass. An adult grouse was seen in a brushy area nearby when the chicks finally scurried off. We believe that this observation represents a Turkey Vulture preying on live, wild Ruffed Grouse chicks.

Observations of Turkey Vultures taking live prey are not common. Glading and Glading (1970), Mueller and Berger (1967), and Scott (1892) reported Turkey Vultures eating live birds, and Jackson et al. (1978) noted Black Vulture (*Coragyps atratus*) and Turkey Vulture capturing live fish. Only the last of these involved a largely natural situation with both predator and prey free.

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Range Extension of Atlantic Puffin and Razorbill in Hudson Strait

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Gaston, Anthony J. and Michael Malone. 1980. Range extension of Atlantic Puffin and Razorbill in Hudson Strait. Canadian Field-Naturalist 94(3): 328–329.

Atlantic Puffins (*Fratercula arctica*) and Razorbills (*Alca torda*) were seen at Digges Sound, Quebec and Northwest Territories, far beyond their known breeding ranges, in August 1979; suggestive evidence of breeding was obtained for Puffins.

Key Words: Atlantic Puffin (*Fratercula arctica*), Razorbill (*Alca torda*), Digges Sound, breeding range, aquatic birds, new records.

During August 1979 we visited the large Thick-billed Murre (*Uria lomvia*) colonies situated on Digges Sound, at the northwestern tip of Quebec (62°30′N, 77°40′W), to make a preliminary survey of seabird populations in the area. In the course of our visit we obtained strong evidence that small populations of Atlantic Puffins (*Fratercula arctica*) and Razorbills (*Alca torda*) occur in this area, well beyond the previously known limits of their breeding range.

The observations of Puffins we owed to our Inuit boatmen, Adami Mangiuk and Ituq Ainalik. After they described the birds to us and identified them in our field guide, they took us on 24 August to a small island, 0.5 km long, off the southwestern coast of Digges Island, Northwest Territories (62°31′N, 77°59′W). As we approached the north side of the island, which rises to a height of 40 m, about a dozen Puffins flew off the cliffs and several others took off from the sea. By the time we landed approximately 40 birds, including at least one carrying a bill-full of fish, were circling around just off the cliffs.

The cliffs consisted of small precipitous rock faces broken by steep ledges covered in thick grassy turf. Four Puffin burrows were located 20–30 m above the sea, but although one contained fresh droppings no chicks were found. Adami saw an adult bird enter a burrow in a rock cleft, but we were unable to detect a chick. Egg-shell fragments of the right color and dimensions to have belonged to a Puffin were also found.

According to Adami, Puffins have been present on the islet for some years. L. M. Tuck, who visited the Digges Sound colonies in 1955 (unpublished data, Canadian Wildlife Service), made no mention of Puffins in the area. Even if he had not visited the vicinity of their islet, he would probably have been informed

by his Inuit assistants had they been present. It seems probable, therefore, that the Puffin colony has become established during the last 20 years.

Razorbills were observed on 3 d between 20 and 27 August along the cliffs at the extreme southwest end of the murre colony on the mainland side of Digges Sound. Three birds were seen on the water on the day that we arrived and subsequently one or two birds were seen circling in front of the cliffs on the south side of Akpa Cove on several occasions. The cliffs in the immediate vicinity supported about 500 pairs of Thick-billed Murres, an outlying group on the extreme edge of the colony. No Razorbills were actually seen landing on or taking off from the cliffs, and their breeding status remains in question.

Tuck (*op. cit.*) made no mention of Razorbills in his report on Digges Sound, but he did mention that he camped for several weeks in Akpa Cove. It seems inconceivable that he could have overlooked the birds had they been present in 1955. Surprisingly, our Inuit companions had no knowledge of Razorbills and had never identified them, although their knowledge of other birds was quite detailed. It thus seems reasonable to assume that Razorbills have colonized the area very recently and they may not yet be breeding.

According to Godfrey (1966) and Brown et al. (1975) the nearest breeding colonies of Puffins to Digges Sound are in Labrador (56° N, 60° W) and west Greenland (64° N, 52° W), both areas being approximately 1300 km away. Razorbills nest in very small numbers in the Harper Islands, Loks Land (V. C. Wynne-Edwards, *in* Godfrey 1966), 650 km from Digges Sound, but otherwise the nearest breeding populations are in the same areas as the nearest Puffin colonies. Todd (1963) quoted I. A. McLaren's sight records of Puffins near Cape Hopes Advance in July 1951, and there and off Cape Wolstenholme (near Digges Sound) in August 1955, but considered those records as exceptional.

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Sorex palustris on Prince Edward Island

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Thomas, Howard H., Gwilym S. Jones, and Randall L. Dibblee. 1980. *Sorex palustris* on Prince Edward Island. Canadian Field-Naturalist 94(3): 329–331.

The first specimens of the water shrew from Prince Edward Island are reported. Habitat is described and habitat associates and ectoparasites are listed.

Key Words: water shrew, *Sorex palustris*, mites, Prince Edward Island, new records, ectoparasites, habitat.

Two Water Shrews, *Sorex palustris*, a male and female, were collected 1 km W of Sturgeon on Route 317, Kings County, Prince Edward Island on 7 July 1977. Another male had been collected on 29 July 1969 at Whitlock's Pond, Bridgetown, Kings County but was not previously reported. Although the Water Shrew is known to occur on the adjacent mainland areas from the Gaspé Peninsula, Quebec southeast to Cape Breton Island, Nova Scotia (Hall and Kelson 1959), these three specimens represent the first records on Prince Edward Island.

All three were preserved as fluid specimens and deposited in the Northeastern University Vertebrate Collection (NUVC); the skulls were removed, cleaned, and measured. Ectoparasites were collected by searching through the fur using a dissecting microscope and by washing the specimens with Alconox detergent, filtering the wash solution and recovering ectoparasites from the filter paper.

The two shrews collected near Sturgeon were trapped in a brush pile under one of numerous deadfall spruce trees, *Picea* sp., in a disturbed, swampy area about 40 m from the Sturgeon River. Four other species of small mammals were collected at the same locality, the Masked Shrew, *Sorex cinereus*, Southern Red-backed Vole, *Clethrionomys gapperi*, Meadow

Vole, *Microtus pennsylvanicus*, and Meadow Jumping Mouse, *Zapus hudsonius*. The individual obtained at Whitlock's Pond was found underneath a Muskrat, *Ondatra zibethicus*, nest near the pond's edge.

Except for greatest breadth of braincase and length of maxillary toothrow, the Prince Edward Island specimens are generally smaller than those from the adjacent mainland (Table 1). But only maxillary breadth is dramatically smaller. Total and tail length are considerably shorter because of the small size of the female specimen. Although the external measurements of the female are small, its skull measurements are the largest of the three. Further, the skull of the female appears no younger than a subadult, according to Jackson (1928) and it is only slightly if any younger than the other two specimens. In order to determine whether the Water Shrews on Prince Edward Island are phenotypically distinct from mainland populations, additional specimens will have to be secured from the island and statistically compared with large samples of mainland specimens.

The following four species of mites (numbers collected in parentheses) were the only ectoparasites obtained from the three Water Shrews: *Orycteroxenus soricis* (6), *Haemogamasus ambulans* (1), *Hirstionyssus talpae* (4), and *Neotrombicula microti* (1). According to Whitaker and Wilson (1974), these represent the first records of mites from Prince Edward Island. All have been reported, however, from Water Shrews in Minnesota (Whitaker and Schmeltz 1973), except for *Hirstionyssus talpae* which has been reported from this host in Carbon County, Utah (Allred and Beck 1966). *Haemogamasus ambulans* has also been found on Water Shrews in North Carolina (Whitaker et al. 1975).

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TABLE 1—Mean measurements (n) and range (in millimetres) of adult *Sorex palustris* from eastern North America

Location	Total length	Tail length	Hind foot length	Greatest breadth braincase[1]	Least interorbital breadth[1]	Length maxillary toothrow[1]	Maxillary breadth[1]
Prince Edward Island	120.5(2), 107–134	52.3(3), 37–62	17.3(3), 17–18	10.1(1)	3.7(1)	7.2(3), 7.2–7.3	5.0(3), 4.6–5.2
Nova Scotia[2]	154.3(2), 150.5–158.0	68.3(2), 66.5–70.0	20(2), 19–20	10.1(2), 10.0–10.1	4.4(2), 4.3–4.4	7.1(2), 7.1	5.6(2), 5.5–5.6
Quebec (Gaspé)[3]	164(2), 154–174	73.6(5), 69–77	20.4(5), 20–21	9.8(3), 9.7–10.0	3.9(5), 3.8–4.1	7.6(5), 7.5–7.7	6.2(4), 5.6–6.5
Labrador[4]	150.5(2), 146–155	73(2), 71–75	20(2), 20	9.8(2), 9.7–9.9	4.2(2), 3.9–4.4	7.7(2), 7.7	5.9(2), 5.8–5.9
West Virginia[5]	153.3(3), 152–155	68.3(3), 64–71	19.7(3), 19–20	10.5(2), 10.3–10.6	3.9(3), 3.8–3.9	8.0(3), 7.9–8.1	6.5(3), 6.4–6.5
Tennessee[6]	141.4(9), 136–148	60.3(9), 58–64	18.1(9), 18–18.5	—	—	—	—
North Carolina[7]	148(5), 138–160	63.2(5), 58–68	19.2(5), 18–20	10.5(5), 10.1–10.9	4.1(5), 4.0–4.1	—	5.8(5), 5.7–6.0

[1]Skull measurements, including those of other authors, taken according to Jackson (1928).
[2]Jackson (1928).
[3]Johnson (1951).
[4]Burt (1938).
[5]Hooper (1942).
[6]Conaway and Pfitzer (1952).
[7]Whitaker et al. (1975).

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Physical Characteristics of Woodland Caribou in Northeastern Alberta

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Fuller, Todd K. and Lloyd B. Keith. 1980. Physical characteristics of Woodland Caribou in northeastern Alberta. Canadian Field-Naturalist 94(3): 331–333.

Weight, body measurements, antler characteristics and timing of antler drop were recorded among radiocollared Woodland Caribou (*Rangifer tarandus caribou*) during a study in northeastern Alberta. Adult cows (> 3 yr) and young bulls (1–3 yr) were of similar size, retained antlers of the same size and shape through winter, and were therefore frequently indistinguishable from the air.

Key Words: Woodland Caribou, *Rangifer tarandus caribou*, Alberta, antlers, body size, weight, measurements.

Estimation of herd composition and calf survival among ungulates often depends on aerial identification of the sexes and of three age classes — adults, yearlings, and calves. The sexing and aging of Caribou (*Rangifer* spp.) are mainly based on differences in body size, antler size and morphology (Bergerud 1971; Parker 1972), and annual cycles of antler shedding (Bergerud 1976). Unfortunately, body-size differences are often indistinguishable from fixed-wing aircraft (Bergerud 1971), and different sex and age cohorts may have similar antler size and morphology (Kelsall 1968; Skoog 1956).

While radiotagging Woodland Caribou (*Rangifer tarandus caribou*) in northeastern Alberta, we noted that it would be difficult, if not impossible, to determine the age and sex of some individuals from the air using body size and antler characteristics. Subsequent observations of radiocollared individuals also indicated a broad overlap in chronology of antler shedding.

Misidentification of specific sex and age cohorts in Woodland Caribou populations could lead to serious misinterpretations of population data. This note intends to alert Caribou biologists to the potential magnitude of these difficulties.

Study Area and Methods

Woodland Caribou were captured and radiocollared during March 1976 – November 1977 in the Birch Mountains and immediately south to the MacKay River, 80–140 km NW of Fort McMurray, Alberta. Standard body measurements were recorded, as was the total main-beam length (base to tip) of each antler. A tooth (C_1) was pulled for age determination from tooth-cementum annuli (Miller 1974). For comparison, 35-mm photographs were taken of antlers of most individuals. Weights were taken by suspending animals from a helicopter in a sling attached to a scale with a 910-kg capacity. Radiocollared Caribou were relocated at weekly intervals during September–October and in May, and biweekly at other times; presence or absence of antlers was noted.

Results and Discussion

Mean weights and body measurements of young bulls (1–3 yr old) and adult cows (> 3 yr old) were similar (Table 1). Adult bulls were notably larger, and calves smaller.

Of the 151 distinguishable cows observed incidentally during flights to relocate radiocollared individuals, 92% had antlers. This contrasted with 9–80% among Caribou in Newfoundland (Bergerud 1976). Antlers of young bulls and most adult cows were similar in length (30–60 cm), but those of adult bulls

TABLE 1—Mean ± SE for weights and selected body measurements of Woodland Caribou captured from March 1976 to November 1977 on the Birch Mountain Study Area

Age and sex[a] (N)	Weight[b], kg	Total length, cm	Chest girth, cm	Neck girth, cm	Head length, cm
Adult bull (17)	190 ± 28.1	219 ± 2.5	154 ± 1.5	77 ± 1.3	51 ± 0.6
Young bull (6)	145 ± 10.5	197 ± 1.9	141 ± 3.5	67 ± 1.8	46 ± 1.5
Adult cow (7)	136	196 ± 1.7	141 ± 4.3	62 ± 0.9	44 ± 0.6
Young cow (3)	No data	198 ± 9.7	137 ± 3.4	55 ± 3.3	43 ± 1.3
Calf cow (3)	No data	184 ± 7.6	122 ± 8.3	53 ± 1.6	38 ± 0.3

[a]Adult, > 3.0 yr; young, 1.0–3.0 yr; calf, < 1.0 yr. Ages determined from tooth-cemetum annuli.
[b]Weights were determined for only three adult bulls, four young bulls, and one adult cow.

averaged about twice as long (Figure 1). Only cows with antlers < 30 cm could be distinguished from young bulls. Two of three female calves had antler spikes measuring 8–10 cm. Antler shape and form was not consistently different between cows and young bulls either (Figure 2).

The annual cycle of antler growth and shedding among our radiocollared Caribou was similar to that described by Bergerud (1976). Antler growth among bulls 3–8 yr old began in late March, and was somewhat later among older and younger bulls. In July, antlers were large and in full velvet; most were free of velvet by mid-August before the rut. Time of antler drop was related to age; the oldest bulls began in early November but some young ones carried antlers until mid-April (Figure 3).

We first observed antler growth on cows in early July. Four radiocollared cows retained antlers until they calved in May; a 3-yr-old lost her antlers in late April and calved in early June.

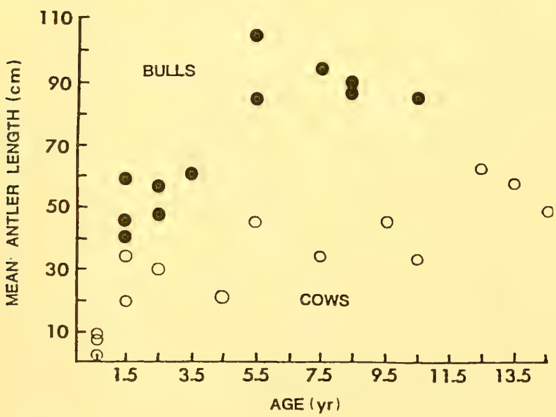

FIGURE 1. Relationship between mean antler length (main beam) and age of Woodland Caribou captured during November 1976 – November 1977 on the Birch Mountain Study Area. Ages were determined from tooth-cemetum annuli.

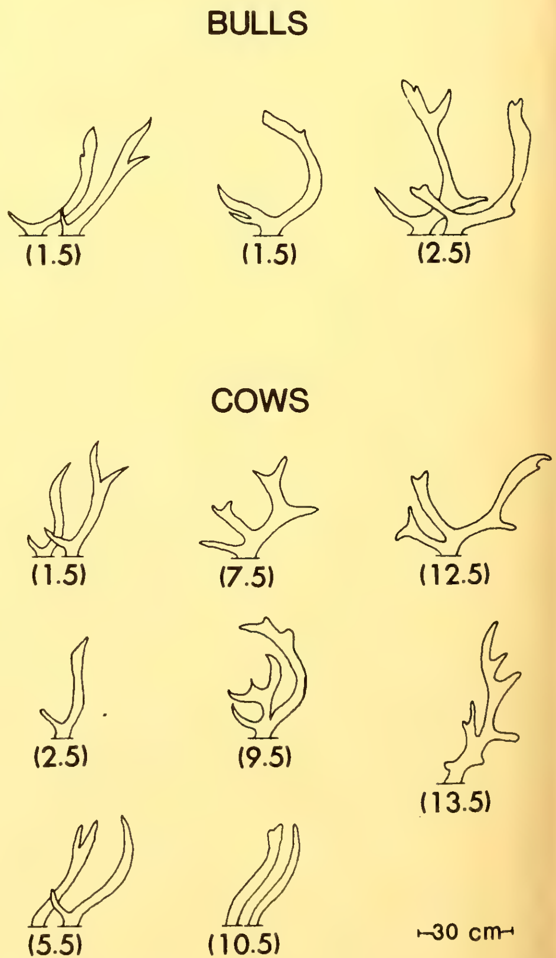

FIGURE 2. Antler morphology of young bull (1–3 yr old) and cow (> 1 yr old) Woodland Caribou captured during November 1976 – November 1977 on the Birch Mountain Study Area. Ages (shown in parentheses) were determined from tooth-cemetum annuli.

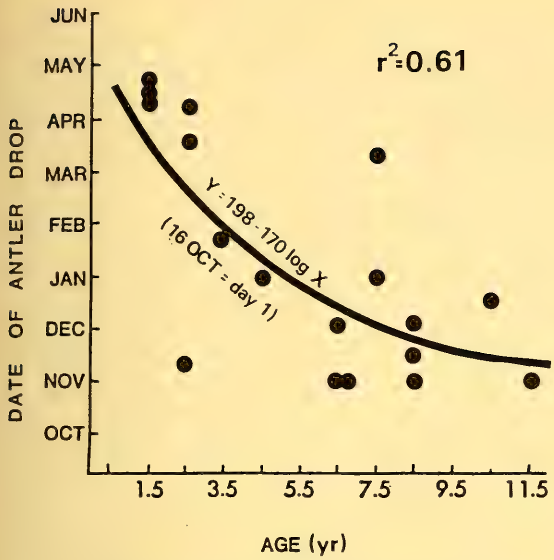

FIGURE 3. Relationship between age and date of antler drop among radiocollared bull Woodland Caribou during March 1976 – June 1978 on the Birch Mountain Study Area. Ages were determined from tooth-cementum annuli.

Thus, for a good part of fall and winter, adult cows and young bulls appeared similar in size, retained antlers of the same size and shape, and were therefore largely indistinguishable from the air; adult bulls and calves, however, were easily identified.

Acknowledgments

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Flowering Rush (*Butomus umbellatus*) in the Canadian Prairies

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Staniforth, Richard J. and Katherine A. Frego. 1980. Flowering Rush (*Butomus umbellatus*) in the Canadian Prairies. Canadian Field-Naturalist 94(3): 333–336.

Three colonies of Flowering Rush (*Butomus umbellatus*) are reported for southern Manitoba. These are the first known colonies of this species in the Canadian Prairies. The pattern of spread in eastern Canada suggests that this aggressive emergent will colonize river edge and pond communities throughout the prairie region. Two types of dispersal are apparent: a short-distance dispersal by water, ice, and animals, and a long-distance dispersal by human aid.

Key Words: *Butomus umbellatus*, Flowering Rush, Manitoba, emergent, aquatic, dispersal, new records.

The first North American observations of *Butomus umbellatus* (Flowering Rush) were made in 1897 at LaPrairie, Quebec (Marie-Victorin 1908). Its subsequent spread has been fairly rapid and well documented. Scoggan (1978) cites reports of stations along the St. Lawrence and Ottawa rivers, and Nova Scotia. Despite its successful spread in an easterly direction, no colonies have been reported in Canada west of the

St. Clair region. In this note, we report three isolated colonies in Manitoba, approximately 1400 km NW of the nearest previously reported Canadian station. Furthermore, we discuss the origin of the Manitoban populations and make some predictions on the future spread of this species in central Canada, based on an examination of its pattern of spread in eastern Canada.

Manitoba Colonies

During summer 1977, we discovered colonies of *B. umbellatus* in a marsh at Patricia Beach, Manitoba and in a small pond near Lockport, Manitoba. Specimens were collected and are on file at the University of Winnipeg (UWPG 0125 and 0125A). A photograph of a flowering umbel from the Lockport colony is shown in Figure 1. At both sites, the plants were standing in approximately 30 cm of water. They occurred with plants of *Typha latifolia* (Broad-leaved Common Cattail) and *Sparganium eurycarpum* (Bur-reed) at Patricia Beach, and with *T. latifolia, Alisma triviale* (water-plantain), *Sagittaria cuneata* (arrowhead), and *Lemna minor* (duckweed) at Lockport. The Lockport colony was well established, with about 10 clumps, each 1 m or more in diameter, and possessing numerous flowering shoots. The Patricia Beach colony consisted of scattered flowering plants in a large stand of Cattails.

FIGURE 1. Flowering umbel of Flowering Rush (*Butomus umbellatus*) from a new Manitoba colony at Lockport, Manitoba.

Examination of herbarium material or correspondence with curators (CAN, DAO, WIN, MMMN, WNRE) revealed a third Manitoban colony at Netley Marsh, Manitoba from which collections have been made since 1964. (DAO 52394, 52395, 140108; CAN 399464; WIN 4441, 15071, 15072, 26142, 30293).

The origin of Manitoba plants is unknown, but we suggest that they arose from the colonies in the Great Lakes region: comparison with mean values for stem length, stem width, longest pedicel, flower number, and petal length obtained by Anderson et al. (1974) showed a higher degree of similarity to plants of the Great Lakes region than to plants of the St. Lawrence River Valley. Anderson et al. (1974) suggested that the tall-stemmed, many-flowered plants established in the Great Lakes and Idaho originated from Europe, whereas smaller plants from the St. Lawrence more closely resemble Asiatic material (sometimes known as *B. junceus*). *Butomus umbellatus* has been reported recently from several of the northcentral United States (South Dakota by Martin 1965; Montana by Hahn *in* Godfread and Barker 1975; North Dakota and Minnesota by Godfread and Barker 1975). Because the appearance of the isolated colonies is chronologically very close, it is unlikely that they are the result of spread from a single introduction into the prairie region. They are more likely to be the descendants of multiple introductions from several sources.

Future Spread in the Canadian Prairies

The occurrence of *B. umbellatus* in the northern United States and in Manitoba, together with the aggressive way by which this species is capable of displacing indigenous riparian vegetation and its wide range of ecological tolerance (Dansereau 1957; Roberts 1972) strongly suggests that it will become an abundant and widespread species in freshwater marshes of the Canadian prairies in the near future. It is unlikely to colonize the margins of saline sloughs, however, because it is apparently intolerant of saline or brackish water (Rousseau 1968; Gauthier 1972). Predictions on the future pattern of spread were made by examination of its prior dispersion in eastern Canada and by knowledge of its dispersal mechanisms. Figure 2(a) shows its known Canadian distribution; Figure 2(b) details its spread in the western Lake Erie region and Figure 2(c) along the St. Lawrence River, as drawn from records in the National Herbarium and the Herbarium of the Canada Department of Agriculture, Ottawa. Two conclusions are forthcoming from this map. (1) New colonies appear in isolated locations at irregular intervals, as in Manitoba, Prince Edward Island, and Nova Scotia. (2) There is local expansion of colonies. Downstream spread has been noted by Stuckey (1968) in western Lake Erie, and Knowlton

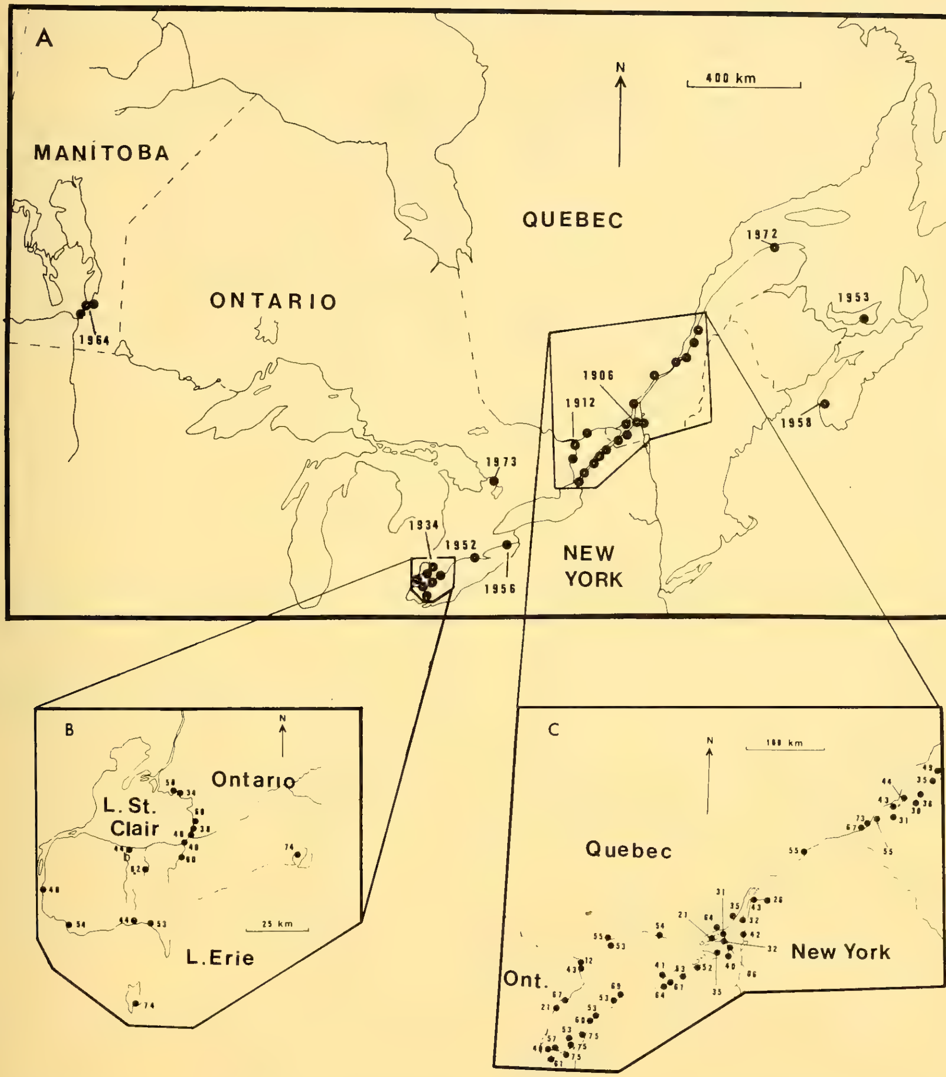

FIGURE 2. (a) Canadian distribution of *Butomus umbellatus* showing the dates of earliest known specimens from each region. (b) Detail of distribution in the Lake St. Clair district and (c) the Ottawa and St. Lawrence river valleys. Distributions were mapped from specimens in the following herbaria: CAN, DAO, WIN, and UWPG.

(1923) in the St. Lawrence River. We suggest that separate dispersal mechanisms may effect long-distance dispersal and colony expansion (short-distance dispersal).

Human assistance has probably effected long-distance dispersal and resulted in the establishment of colonies in Nova Scotia (Hall 1959), Prince Edward Island (Groh *in* Scoggan 1978), Kent County, Ontario (Gaiser 1949), and Hamilton, Ontario (Dempsey 1934). Short-distance dispersal has been attributed to different dispersal agents by different authors. Ridley (1930) has observed that seeds float for 1 or 2 d, if fresh, or longer if dry or invested with a fungal mycelium. Marie-Victorin (1938) noted numerous bulblets which separate from the rhizomes and become dispersed by water currents. Gauthier (1972) suggests that dispersal may be effected by ice movements and Gaiser (1949) has noted that plant parts were trans-

ported by Muskrats (*Ondatra zibethicus*) during house-building activities. None of these proposals has been verified to determine subsequent viability of propagules, but it seems likely that several dispersal agents may be involved. The ability for seeds to remain viable for long periods of time (68% germination after 5 yr storage in water, (Muenscher 1944)) increases the chances that seeds will be dispersed (Staniforth and Cavers 1976).

Acknowledgments

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Behavior of Common Terns Nesting near Ring-billed Gulls

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The behavior of Common Terns (*Sterna hirundo*) nesting near Ring-billed Gulls (*Larus delawarensis*) was studied in 1978 and 1979 at the Eastern Headland, Toronto, Ontario. Interactions with gulls occurred infrequently (0 to 1.11/tern nest·h^{-1}) and were brief (mean 18.4 s). Incubation attentiveness, time spent on territory by the off-duty tern, and number of shift change-overs were not influenced by proximity to nesting gulls. During 1570 nest-h of observation no predation of a tern egg or chick was noticed. Ring-billed Gulls appeared to have little effect on Common Terns once nesting had begun.

Key Words: Common Tern, *Sterna hirundo*, Ring-billed Gull, *Larus delawarensis*, breeding, interaction, interspecific relationships, predation.

At a Common Tern (*Sterna hirundo*) colony at Port Colborne, Ontario, Hunter (1976) found that Ring-billed Gulls (*Larus delawarensis*) had no significant effect on the reproductive success of the terns nesting in close proximity. Yet Ring-billed Gulls have been known to eat eggs (Courtney 1979) and chicks (Hun-

ter 1976, p. 100) of Common Terns at that site. Morris and Hunter (1976) mentioned that direct interactions between the two species were infrequent and of low intensity although no data were presented. Haymes and Blokpoel (1978) also found that nesting Ring-billed Gulls had no significant effect on the reproductive success of Common Terns that nested near those gulls at the Eastern Headland. In 1978 and 1979 we studied gull-tern interactions to determine (1) the frequency of egg and/or chick predation by gulls, (2) the frequency and nature of gull-tern interactions in areas where the two species nested side by side, and (3) the effects gulls nesting nearby had on the incubation behavior of the terns. In this paper we present and discuss the results of that study.

Study Area

The Eastern Headland in Toronto Outer Harbour, Lake Ontario, is connected to the mainland and comprises about 103 ha. Created by landfill operations beginning in 1967, it was first colonized by Common Terns in 1971 and by Ring-billed Gulls in 1973 (Blokpoel and Fetterolf 1978). Peak counts of nests with eggs during the 1976, 1977, and 1978 nesting seasons were as follows: Common Terns — 1246, 1238, 1310, and Ring-billed Gulls — 10 382, 20 564, 22 735, respectively. In 1979 the peak count for Common Terns was 1484 nests with eggs and we estimated that there were at least 31 000 Ring-billed Gull nests with eggs. From 1977 to 1979 Ring-billed Gulls began laying eggs between 17 and 23 April while Common Terns began between 4 and 10 May. As new areas are still being colonized, and as both gulls and terns are still increasing in number, there appears to be little indication at this time of the terns being crowded out by the gulls.

Methods

Observations in 1978 and 1979 were from one-man canvas blinds placed in different parts of the colony. In 1978, we observed pairs of terns for periods of 3–4 h at different times of the day between 07:00 and 21:00 and at different phases of incubation in three mixed-species areas. Between 15 June and 6 July, 56 h (226 nest-h) were spent observing nine tern nests; all were 1.2 to 4.6 m ($\bar{x}$ = 2.9 m) from the nearest Ring-billed Gull nest. In 1979, four observers made observations simultaneously in four areas that differed with regard to distance from tern nests to nearest Ring-billed Gull nests. Nests for observation in 1979 were selected on the basis of similar dates of clutch initiation (12–14 May), and in each area five Common Tern nests were observed from 09:00 to 13:00 on 15, 16, 17 May (egg-laying), 23, 24, 25 May (mid-incubation), and on 4, 5 June (hatching). One hour at the beginning of each 4-h observation period was allowed for the birds to quiet down after we entered the blinds. One member of each of the 20 tern pairs observed was captured (using a walk-in trap placed over the nest), banded, and marked with red nail polish on the neck on 18 May.

In both 1978 (with limited success) and 1979 we recorded, (1) number and nature of interactions with Ring-billed Gulls, (2) time spent on the nest by the 'on-duty' bird, (3) time spent on territory by the 'off-duty' bird, and (4) number of incubation shift change-overs. Between 6 and 22 June 1979, an additional 108 h (864 nest-h) was spent observing from blinds possible chick predation by gulls. We define an interaction as either a chase or flight reaction (i.e., when a tern chased a gull or when a tern fled from a gull).

Results and Discussion

All pairs observed in 1978 were late-nesting birds, that is, they initiated clutches after the peak nesting period. As the Ring-billed Gulls had already hatched many chicks by the time we started our observations, some interactions (36%) involved those chicks. The number of interactions (N = 33) with the gulls varied from 0 to 1.11 ($\bar{x}$ = 0.25)/nest$\cdot$h^{-1}. All interactions involved a tern chasing a gull, with 64% of the chases involving the off-duty tern and 36% the on-duty tern. We do not have accurate information on the duration of the chases. There was no particular time of day when interactions were obviously more numerous, although there was a tendency for reduced activity after 18:00. Incubation attentiveness was high both during the mid-incubation phase ($\bar{x}$ = 99.3% of time spent on nest), and during hatching ($\bar{x}$ = 97.8%). We obtained insufficient data on time spent on territory by the off-duty bird and the number of incubation shift change-overs in 1978 because our birds were not marked and some were obscured by vegetation.

In 1979 we selected nests in areas where vegetation was sufficiently sparse that the territory of each nesting pair could be observed. The terns we observed in 1979 were early nesters and, as Ring-billed Gull chicks did not begin to hatch until 26–27 May in the study areas, there were no interactions involving gull chicks during the egg-laying and mid-incubation phases. The number of interactions varied from 0 to 0.18 interactions/nest$\cdot$h^{-1}, and there were no interactions with Ring-billed Gulls in areas 3 and 4 where distances between tern and gull nests were greater (Table 1). The number of interactions did not seem to be related to the stage of incubation. In total we observed 25 interactions with Ring-billed Gulls, 19 (76%) of which involved chases, by off-duty birds, lasting 5–60 s ($\bar{x} \pm$ SE = 18.4 $\pm$ 3.86), and 6 (24%) involved chases by birds leaving eggs, lasting 10–35 s (16.7 $\pm$ 4.01). Two interactions involved Ring-billed Gull chicks, the others involved adults.

TABLE 1—Nest attentiveness of Common Terns and interactions with Ring-billed Gulls at the Eastern Headland in 1979, (*a*) during egg-laying, (*b*) during incubation, (*c*) during hatching, Means ± SE

Study area	No. clutches	Distance to nearest gull nest (m)	Mean no. interactions with gulls/ nest·h^{-1}	Mean % total time nest covered	Mean % time on territory by off-duty bird*	Mean no. incubation changeovers/ nest·h^{-1}
1	5	2.8 ± 0.41	(*a*) 0.16 ± 0.10	95.7 ± 1.62	68.9 ± 2.52	—**
			(*b*) 0	97.6 ± 0.85	69.4 ± 1.76	1.4 ± 0.16
			(*c*) 0.17 ± 0.13	99.3 ± 0.07	48.4 ± 6.58	2.0 ± 0.14
2	5	5.4 ± 1.06	(*a*) 0.04 ± 0.03	97.0 ± 0.34	62.2 ± 2.57	—
			(*b*) 0.18 ± 0.08	99.5 ± 0.06	62.0 ± 3.95	1.0 ± 0.15
			(*c*) 0.10 ± 0.07	98.9 ± 0.22	47.8 ± 7.22	1.6 ± 0.13
3	5	11.0 ± 0.76	(*a*) 0	96.7 ± 0.66	64.2 ± 4.19	—
			(*b*) 0	98.5 ± 0.05	60.3 ± 4.55	1.2 ± 0.17
			(*c*) 0	98.1 ± 0.02	49.0 ± 5.91	1.8 ± 1.00
4	5	32.2***	(*a*) 0	98.8 ± 0.23	64.1 ± 3.45	—
			(*b*) 0	99.5 ± 0.06	65.0 ± 3.84	1.1 ± 0.06
			(*c*) 0	99.7 ± 0.14	39.8 ± 6.78	1.3 ± 0.15

* Percent of total time/nest·h^{-1}.
** Not accurately determined because birds were not marked during that period.
***Minimum distance measured hence no standard error.

There were no apparent trends in the other variables measured with regard to proximity to nesting Ring-billed Gulls (Table 1). There were no significant differences between the group of birds that experienced interactions with Ring-billed Gulls (areas 1 and 2 pooled) and those that did not (areas 3 and 4 pooled) at any of the different phases of incubation ($P > 0.05$, Mann-Whitney U-tests). As a comparison, the 10 pairs of terns in areas 1 and 2 experienced the following frequencies of interaction with neighboring Common Terns: egg-laying — 0.14 ± 0.044 interactions/nest·h^{-1}, mid-incubation — 0.11 ± 0.033, and hatching — 0.13 ± 0.102. The frequency of interactions with members of its own species was thus equal to, or higher than, the frequency of interactions with Ring-billed Gulls (see Table 1).

Terns become habituated to the presence of predatory gulls nesting nearby (McNicholl 1973). Aggressive responses continue to be shown after habituation, but those responses are principally dependent upon distance of approach and degree of movement by the potential predator (Veen 1977). Habituation may account for the low frequency of interactions we observed between the gulls and terns. During 260 h (1570 nest-h) of observation in 1978 and 1979 we observed no instances of egg or chick predation by Ring-billed Gulls. At least at the Headland, predation by Ring-billed Gulls is rare. Hence Common Terns may not react to Ring-billed Gulls as predators but rather respond as they would to members of their own species that came too close.

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Wolverine Marking Behavior[1,2]

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Koehler, Gary M., Maurice G. Hornocker, and Howard S. Hash. 1980. Wolverine marking behavior. Canadian Field-Naturalist 94(3): 339–341.

Observations on Wolverine (*Gulo gulo*) marking were made during a Wolverine study in Montana. Marking stations generally were established sites used over several years. Marking involved marking visual and olfactory signs on the ground or on the trunk of a tree. Several Wolverines used a single marking station. Marking, rather than being a mechanism for maintaining a mutually exclusive territory, probably serves to maintain the essentially solitary nature of the Wolverine, maintaining time but not area spacing.

Key Words: marking, scent, home range, Wolverine (*Gulo gulo*).

Scent marking must be an important form of communication among Wolverines (*Gulo gulo*) as indicated during this study, by the energy expended to mark. They will mark as many as 20 sites per 2.5 km of travel, and will alter their travel routes to mark or investigate a site. Scent marking is also a major communication form among other mammals (Eisenberg and Kleiman 1972; Johnson 1973; Ralls 1971). We conducted this study to explore the social intent of marking behavior among Wolverines.

Methods

During the 1975–76 and 1976–77 winter seasons we observed Wolverine marking behavior while snow-tracking Wolverine a total of 153 km. The study was conducted on the Bob Marshall Wilderness in northwest Montana (47°20′N, 113°20′W). Most of the observations of marking were interpreted from tracks in the snow; only one Wolverine was seen marking.

We recorded the tree species that were scent marked and measured their diameter at breast height, the height a Wolverine climbed a tree to mark, and the height of the scent mark on the trunk from the base of the tree. A description of marking signs left in the snow was also recorded.

Results and Discussion

Four different methods of marking were observed: (1) climbing a tree and depositing musk either on the tree trunk or on the ground, (2) scratching the ground in a manner similar to that of a domestic dog with or without deposition of musk on the site, (3) gnawing or biting a limb or root scented with musk; and (4) depositing a scat or musk on the ground without leaving other visual signs.

Climbing up the tree and depositing musk on the trunk or the ground occurred on approximately 70% of 157 marking sites. In order to mark the trunk while in the tree, the Wolverine apparently placed its anal or ventral region against the trunk. To mark the ground the anal region would be held away from the trunk. Claw marks were evident on trunks an average height of 171 cm to a maximum height of 210 cm. Musk was seen and smelled on trunks an average height of 46 cm to a maximum height of 74 cm from the base.

Marking signs left in the snow were scratch marks similar to those of a domestic dog. One Wolverine was seen scratching the ground.

Wolverine marking sites generally were well established and used both winters of this study. Claw marks on the trees indicated they were used during years prior to this study. Twenty sites along 5 km of trail were observed to be marked from one to eight times during the two winters (Table 1). Wolverine would, however, mark previously unmarked sites. One Wolverine was observed marking 20 different sites during 2.5 km of travel. The closest distance between marking sites was 1.5 m. At times a Wolverine would travel several kilometres between marking sites. Tracking indicated that they often veer off a travel route and go directly to a marking site. Occasionally a passing Wolverine would only investigate and not mark, or would completely ignore a marking site.

Marking sites tended to be prominent trees in an area, those of large diameter or those isolated in meadows or along trails. All species of trees were marked, but Lodgepole Pine (*Pinus contorta*), the most common tree species, was most often marked. They would often deposit scent on Coyote (*Canus latrans*) scats and Coyote scent stations and hummocks of snow

[1]Contribution of the Idaho Cooperative Wildlife Research Unit, United States Fish and Wildlife Service, Idaho Department of Fish and Game, University of Idaho, and the Wildlife Management Institute cooperating.
[2]University of Idaho College of Forestry, Wildlife and Range Sciences, Publication Number 177.

TABLE 1—Description of Wolverine sites along two 2.5-km sections of trail

Site identification number	Tree species	Tree dbh (cm)	Number times marked	Winters used	Predominant method of marking site*	Number of Wolverine using site**
A-1	*Abies lasiocarpa*	51	4	Both	2	—
2	*Pseudotsuga menziesii*	51	5	Both	1	—
3	*Pinus contorta*	20	5	Both	1	—
4	*Pseudotsuga menziesii*	30	2	1977	1	—
5	*Pinus contorta*	13	4	1977	1	—
6	*Pinus contorta*	25	5	Both	1	—
7	*Pinus contorta*	25	5	1977	1	—
8	*Pinus contorta*	20	1	1977	1	—
9	*Pinus contorta*	15	1	1977	1	—
10	*Pinus contorta*	15	4	1977	1	—
11	*Pinus contorta*	25	6	Both	1	—
12	*Pinus contorta*	25	3	1977	1	—
13	*Pseudotsuga menziesii*	30	8	Both	1,3	2
B-1	*A. lasiocarpa*	36	4	Both	1	—
2	*A. lasiocarpa*	13	3	Both	4	—
3	*Picea engelmannii*	15	1	1977	4	—
4	*Pseudotsuga menziesii*	46	4	Both	1	2
5	*Pseudotsuga menziesii*	41	3	Both	1,2	2
6	*Pseudotsuga menziesii*	61	2	Both	4	—
7	*Pseudotsuga menziesii*	61	1	1977	4	—

*1—climbing tree and depositing scent on tree or ground, 2—scratching ground with or without depositing scent, 3—gnawing limb or root, 4—depositing scat or scent without leaving other visual signs.
**Dashes, unknown, but one or more

created by small trees, bushes, and rocks. Wolverines also marked sites near baited live-traps. This is the only case where Wolverine behavior was known to have been influenced by the human observers.

At least five sites were marked by at least two individuals. This was determined by the presence of different-sized tracks at the site. In one case, identification was made of a radio-collared individual. Several days later another Wolverine was observed marking the same sites.

On four occasions, at least three males were identified as marking by either radio location, live-trapping, direct observation, or track identification. Females are suspected of at least investigating the marking sites as indicated by the presence of smaller tracks. But no marking was definitely observed for females.

Wolverines in this study required areas up to 963 km^2 for their hunting and scavenging habits. Haglund (1966), Krott (1960), Pulliainen and Ovaskainen (1975) interpreted the function of marking in Wolverines as territorial. Such large areas would be difficult to defend and apparently are not defended as indicated by the often complete overlap of home range areas of animals of the same sex. Marking, rather than being a mechanism for maintaining a mutually exclusive territory, probably serves to maintain the essentially solitary nature of the Wolverine, maintaining time but not area spacing. It may indicate that the area is being hunted by the marking Wolverine and it would be inefficient from an energy standpoint for other Wolverines to hunt the same area. As Kleiman (1966) indicated, response to scent marking may be simple avoidance rather than a response to an antagonistic display of territorial defense.

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Boschniakia rossica, Northern Groundcone, a Vascular Plant New for Alberta

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Lee, Peter G. 1980. *Boschniakia rossica*, Northern Groundcone, a vascular plant new for Alberta. Canadian Field-Naturalist 94(3): 341.

The discovery of *Boschniakia rossica*, Northern Groundcone, a new genus and species to the flora of Alberta, is reported.

Key Words: range extension, Northern Groundcone.

On 24 July 1979, I collected a specimen of *Boschniakia rossica* and deposited it in the herbarium at the University of Alberta (ALTA); its identification was confirmed by the Curator, John Packer. The plant, commonly called Northern Groundcone (McNaughton et al. 1977) was growing on the north slope of the Caribou Mountains in northern Alberta (59°33′N, 115°45′W). Only a single plant was found. In the immediate vicinity of the collection, the dominant tree was White Spruce (*Picea glauca*) and the dominant shrub Green Alder (*Alnus crispa*).

This specimen may represent the southeastern limit of its distribution in North America. The main range of *B. rossica* is in eastern Asia, including Japan (Porsild 1966), but it is frequently found in low and high subarctic regions in western North America, especially Alaska (Scoggan 1979). Its Canadian distribution is restricted to isolated populations. It is locally common or rare in northern British Columbia, Yukon Territory, western District of Mackenzie (Northwest Territories) (Hultén 1968; Porsild 1966) and now northern Alberta. *Boschniakia rossica* lacks chlorophyll and is parasitic on the roots of *Alnus crispa* and *Picea* spp. (Hultén 1968; Scoggan 1979).

The new site represents a range extension of about 110 km from the Kakisa River (60°30′N, 116°25′W) in the Northwest Territories (W. J. Cody, Biosystematics Research Institute, Agriculture Canada, Ottawa, personal communication).

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Large Flathead Chub (*Platygobio gracilis*) from the Peace-Athabasca Delta, Alberta, Including a Canadian Record

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Kristensen, John. 1980. Large Flathead Chub (*Platygobio gracilis*) from the Peace-Athabasca Delta, Alberta, including a Canadian record. Canadian Field-Naturalist 94(3): 342.

Twenty-four of 293 Flathead Chub captured in the Wood Buffalo National Park section of the Peace-Athabasca Delta in 1976 and 1977 were as long as, or longer than, the longest previous Alberta record and one exceeded the previous Canadian record.

Key Words: Flathead Chub, *Platygobio gracilis*, Peace-Athabasca Delta, Wood Buffalo National Park, new records, body size.

Most species of the family Cyprinidae (minnows) are relatively small. The Flathead Chub (*Platygobio gracilis*), however, is an unusual cyprinid in that it sometimes reaches sizes similar to those of some of our game fish species.

The largest Flathead Chub known to McPhail and Lindsey (1970) was one 317 mm total length from the Peel River, Northwest Territories. Prouse and Derksen (1974) reported a Flathead Chub 367 mm total length and 440 g round weight that was captured in Lake Winnipeg, Manitoba in 1973. In Alberta, Flathead Chub up to 254 mm fork length have been taken at Edmonton (Paetz and Nelson 1970) and Kendall (*in* Paetz and Nelson 1970) reported that Francis Harper collected Flathead Chub in the Athabasca Delta area near Fort Chipewyan in 1920 up to 305 mm fork length.

While conducting fisheries research in the Wood Buffalo National Park section of the Peace-Athabasca Delta in northeastern Alberta in 1976 and 1977, we captured a total of 293 Flathead Chub, the majority of which were tagged and released. (For this reason, only length and weight of fish were recorded.) Fish were captured in gill nets (primarily 6.4-cm stretched mesh size) or in a fyke net. Twenty-four of these fish were as long as, or longer (305 mm fork length or greater) than, the longest previous Alberta record; their mean fork length and total length (± SD) were 314.8 ± 9.2 mm and 345.5 ± 10.4 mm, respectively, and the ranges of their fork lengths and total lengths were 305–340 mm and 334–370 mm, respectively. One fish was as long (367 mm total length) as the longest Flathead Chub previously recorded for Canada, and weighed 397 g. The longest fish captured was 370 mm total length (and weighed 510 g), which exceeded the previous Canadian record by 3 mm.

Perhaps the high number of large Flathead Chub occurring in the Peace-Athabasca Delta may be attributed to the ideal habitat and food conditions prevailing there for this species. The delta waters are very turbid, and aquatic and terrestrial insects are abundant. Donald and Kooyman (1977) indicated that corixids (water boatmen) are particularly abundant in the delta. Scott and Crossman (1973) reported that Flathead Chub prefer turbid waters and that their diet consists primarily of insects, corixids being especially important.

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First Record of a Cinnabar Moth, *Tyria jacobaeae,* in Newfoundland

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Larson, David J. and Bernard S. Jackson. 1980. First record of a Cinnabar Moth, *Tyria jacobaeae,* in Newfoundland. Canadian Field-Naturalist 94(3): 343–344.

The Cinnabar Moth, a European moth which was introduced into the maritime provinces for the control of Tansy Ragwort (*Senecio jacobaea*), is recorded from Newfoundland for the first time.

Key Words: Cinnabar Moth, (*Tyria jacobaeae*), Newfoundland, Lepidoptera, Arctiidae.

The Cinnabar Moth, *Tyria jacobaeae* (Lepidoptera: Arctiidae), a strikingly colored grayish-black and vermilion moth, is native to Europe and western Asia. Its larvae feed gregariously, principally upon Tansy Ragwort (*Senecio jacobaea*), but also on several related composites (South 1961). The larvae frequently occur at densities adequate to defoliate completely the host plant. This, coupled with the facts that Tansy Ragwort is a noxious weed of pastures, is toxic to livestock, and has been widely distributed in temperate to cool-temperate parts of the world by the activities of humans, has led to several attempts to introduce Cinnabar Moths into naturalized populations of Tansy Ragwort as biological control agents.

Deliberate introductions have been successful in Australia (Schmidl 1972), New Zealand (Meads 1973), the United States, and since 1966, in Canada (Harris et al. 1971, 1975). By 1975, colonies of Cinnabar Moths were established in British Columbia, New Brunswick, Nova Scotia, and Prince Edward Island. Initial establishment of the moths using imported stock was largely unsuccessful. Once populations had become naturalized, however, establishment of new colonies using naturalized Canadian stocks had a high success so that by 1975 at least 12 colonies existed in Nova Scotia (Harris et al. 1975).

Spread of the moth from release sites has been observed to be slow, for the adult is a weak flier, generally showing only short-range dispersal (Harris et al. 1975).

Recently, one of us (D.J.L.) collected an adult male from the Codroy Valley in southwestern Newfoundland(Junction Trans-Canada Highway and South Branch Codroy River, near Coal Brook, 47°56′N, 58°59′W, 17 June 1979; specimen in Entomology Collection, Department of Biology, Memorial University of Newfoundland). The specimen was captured in flight after it had been flushed from tall grass bordering a small pool in a roadside borrow pit. Neither the identity of the moth nor the significance of the capture was recognized at the time of collection and the area was not searched for additional specimens. Thus the status of the Cinnabar Moth population at this site was not determined.

This specimen was found in one of the three small areas of Newfoundland (Port-aux-Basques–Codroy Valley; St. John's–Holyrood; Croque) from which Tansy Ragwort has been collected (P. Scott, Agnes Marion Ayre Herbarium, Memorial University, St. John's, Newfoundland, personal communication).

The specimen was of bright color and in good condition with only some slight rubbing of the forewings, damage probably done during capture. This, along with the fact that the moths are weak fliers, suggests that the specimen developed near the locality of capture and had not immigrated from one of the known maritime colonies. Therefore, it is possible that a colony of Cinnabar Moths could have been established in southwestern Newfoundland.

The occurrence of the specimen beside the Trans-Canada Highway, within 50 km of the landing of the Nova Scotia ferry, suggests transport by automobile as a possible means of introduction of the species into Newfoundland. Dispersal by flight is also a possibility, because several mainland species of Lepidoptera that do not overwinter or breed in Newfoundland, immigrate into the province with some regularity, probably assisted or transported by the prevailing winds or by storms. Jackson (1978) has postulated wind-assisted dispersal as the mechanism by which the European Skipper reached Newfoundland. G. Mertens (Antigonish, Nova Scotia, personal communication) noticed a population upsurge of the Cinnabar Moth near Antigonish, Nova Scotia in 1979. If this increase was widespread, unusually high numbers of this species may have been dispersing and available for human- or wind-assisted dispersal.

If continued collecting should show that this specimen was unique or that the species has not become established, it may, on the basis of some of the initial

successes with the Cinnabar Moth as a biological control of Tansy Ragwort, be desirable to attempt deliberately to establish this insect in each of the Newfoundland sites in which Tansy Ragwort is known to exist.

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News and Comment

New Honorary Members of The Ottawa Field-Naturalists' Club

In 1979, the centennial year of The Ottawa Field-Naturalists' Club, four people were recognized for their involvement in club activities and/or their professional contributions to the field of natural science. Honorary Memberships and special club pins were presented to C. H. D. (Doug) Clarke, W. J. (Bill) Cody, George H. McGee, and Pauline Snure.

C. D. H. Clarke

Doug is one of Canada's most dedicated naturalists. After receiving his doctorate from the University of Toronto, he carried out a biological survey of the Thelon Game Sanctuary in the Northwest Territories. This brought him to Ottawa, where he joined Hoyes Lloyd's staff in the Department of Mines and Resources, to work in wildlife and fisheries management in national parks in the Northwest Territories and Yukon Territory. In the Yukon he was part of the North Pacific Planning Project, one outcome of which was the Kluane Reserve.

He then went to the Ontario Department of Lands and Forests as the first head of wildlife research. He moved to take charge of wildlife management, and finally became Chief of the Fisheries and Wildlife Division. His advice was eagerly sought and he served as a wildlife consultant for the New York State Temporary Commission on the Future of the Adirondacks. Later he was a wildlife consultant to the Kenya Game Department and more recently to Tanzania National Parks.

In Ottawa, Doug was a Member of Council of The Ottawa Field-Naturalists' Club, served as Editor of *The Canadian Field-Naturalist* in 1939 and 1940, and served as club Treasurer in 1942. He joined the club in 1931 switching to become a subscriber to *The Canadian Field-Naturalist* in 1976 when this option was first offered.

Because of his expertise in wildlife biology and natural history in general, Doug has become well known both nationally and internationally. He has previously been honored by the Wildlife Society (Honorary Member, Leopold Medallist) and the Federation of Ontario Naturalists (Honorary Member, Honorary President). Now we are extremely proud to have him as an Honorary Member of The Ottawa Field-Naturalists' Club.

W. J. Cody

Bill has one of the longest records as an active member of The Ottawa Field-Naturalists' Club, having joined in 1946. As the "perennial" Business Manager of *The Canadian Field-Naturalist*, he has since 1950 monitored stocks of back issues, sold reprints, looked after the membership and subscription mailing list, and carried out public relations for the journal, which has given the club worldwide recognition. Bill has thus provided an invaluable service to the club in this way alone.

He is a frequent contributor to *The Canadian Field-Naturalist* having produced, to date, over 50 scientific papers and reviews for the journal. In 1978 a revised edition of his *Ferns of the Ottawa district* came out. This book was originally published by the Canada Department of Agriculture in 1956. This book has been greatly appreciated by amateur naturalists as well as professional botanists. In conjunction with the late A. E. Porsild, he has written a *Flora of the Continental Northwest Territories*, which is now in press and expected to be published in 1980. This book will be very timely because of the increased exploration and activity in the environmentally sensitive Arctic.

His extraordinary dedication behind the scenes of the club, his managing of the business affairs of *The Canadian Field-Naturalist*, and his scientific contributions to Canadian botany make Bill one of our most outstanding members.

George H. McGee

George's interest in the outdoors began early in his native New Brunswick and led him to a degree in Forest Engineering at the University of New Brunswick. After the war he went to Ottawa where he was employed by the Canadian government first as Assistant Director (Forestry) and then as an Examination Officer in charge of licensing examinations for airmen. Here he crossed paths again with Duncan A. MacLulich and is emphatic that his simple love of outdoors evolved into a deepening appreciation of the broader aspects of natural history through this association.

George joined The Ottawa Field-Naturalists' Club in 1960 and immediately became active in club affairs. He was a long-time Member of Council, served on many committees and as President 1964–1966. His efforts to increase interest in birding and club activities in the early 1960s included his series of lectures at the National Museum on bird identification, for which he used his own slides and photographic enlargements as basic tools. He also organized birding field trips to the Mer Bleue in May and to Shirleys Bay in the fall. The enthusiasm of the participants undoubtedly contributed to the rapid growth of the club. In addition to leading field trips, George appeared on cable television and CBC radio to promote an awareness of natural history. For his personal Canadian

centennial project, he authored the pamphlet *Birds Botany Geology Ottawa Canada* which was sent to all new club members while supplies lasted.

In the early 1970s George once more began his bird identification course using the facilities of the Ottawa Board of Education. He continues to provide talks to youth groups and is regularly sought as a leader for nature walks for senior citizens and other groups.

His popularity and success in the club are largely due to his interest in people as well as his enthusiams for natural history. On outings he quickly spotted newcomers and made a point of welcoming them. He believes education is essential for the solution of environmental problems and his contribution towards conservation is to encourage an appreciation and love of nature, particularly in the young. He continues to give the club enthusiastic support, friendship, and generosity for which we will never be able to thank him sufficiently.

Pauline Snure

A club member since 1941, Pauline Snure was for many years a very active member of the Council, serving on committees and, from 1948 to 1950, as President. She has served also on the executive of other organizations to which she has belonged, among them the University Women's Club of Ottawa, the Professional Institute of the Public Service of Canada, and the Society of Technical Writers and Publishers. Thus, as a graduate in Honor Science from McMaster University, with an M.A. in Botany from McMaster and a Ph.D., also in Botany (Plant Cytology), from the University of Wisconsin, she brought to the club not only a knowledge of biology but also administrative ability, in addition to a lifelong interest in natural history gained at her home in the Niagara Peninsula.

In the 1940s, her enthusiastic assistance with the excursions and lectures contributed to a heightening of members' interest in club activities, and during her term as President, the club had some of its most productive years. Successful enterprises initiated at this time included the building of the Beattie Point Club House, presentation of Audubon Screen Tours, publication of a Newsletter, and formation of the Macoun Field Club. *Trail & Landscape*, the successor of the Newsletter, is now the Club's medium of publication for non-technical articles in natural history, and the thriving Macoun Field Club continues to provide for young people a unique way of studying and enjoying the natural environment.

For more than 30 years, Pauline supervised journal editing and production in the Publication Office, Research Journals, National Research Council of Canada. For the *Canadian Journal of Botany, Canadian Journal of Zoology*, and other research journals, she set very high publication standards, and her experience was often helpful to the club. In an article recently published in *Trail & Landscape,* she gave readers a first-hand glimpse of *The Club Years 1940–1949.*

Prepared, after input from the recipients, from the accounts written by H. Loney Dickson and published in 1979 in *Trail & Landscape* 13(4): 148–151

Symposium on the Scientific Studies of Hudson and James Bay

This Symposium on Multidisciplinary Studies on Hudson and James Bay will be held 28–30 April 1981 at the University of Guelph. The objectives of the symposium are to assess the current state of knowledge; report on research in the area; relate features and processes of this area to other similar arctic and sub-arctic zones; foster interdisciplinary interaction; and determine needs for further research. For information please write to Professor I. P. Martini, Department of Land Resource Science, Ontario Agricultural College, University of Guelph, Guelph, Ontario N1G 2W1; telephone (519) 824-4120 extension 3129.

Resource Kits Available from Interpretation Canada

Through the assistance granted by the Museums Assistance Programme of the National Museums of Canada and with the added support from the Ontario Ministry of the Environment, Interpretation Canada has available ten Resource Kits. These are based on the organization's 1978 Workshop Interpretation for Children . . . of all ages. Kits include notes, articles, bibliographies, resource lists, and ideas. For more information, write to **Interpretation Canada Resource Kits, Box 160, Aylmer, Quebec J9H 5E5.**

Support Available for Field Research

Interested scholars in need of funds and volunteer support for their 1981 field research should contact the Center for Field Research. This private, non-profit organization and its affiliate, Earthwatch, arrange support for 70 research projects each year through the field assistance and financial contributions of interested volunteers.

Proposals are reviewed on the basis of scholarly merit and the project's need for teams of volunteers in the field. There are no limits on geographic location, and proposals in any recognized academic discipline are considered, including the life sciences, social sciences, marine sciences, and humanities.

The Center invites proposals from post-doctoral scholars of all nationalities, and actively encourages women and minority investigators to apply. Upon favorable review of a preliminary proposal, a full proposal will be invited for the 15 May deadline (for work taking place December–June) or the 1 October deadline (for work taking place June–December).

If you are planning field research in 1981, write for more information, or send a two-page preliminary proposal outlining your objectives, dates, and funding and volunteer needs to Nancy Scott, Research Co-ordinator, Center for Field Research, Box 127-Q, 10 Juniper Road, Belmont, Massachusetts 02178 or telephone (617) 489-3032.

Raptor Research Foundation Meeting

The 1980 Meeting of the Raptor Research Foundation will be held 10–13 October in Duluth, Minnesota. Preliminary plans call for special emphasis on the following topics: raptors in third world countries, raptor physiology, telemetry studies of raptor behavior, captive breeding, raptor habitats, raptors in zoos, raptor surveys and dynamics, and raptor migration. Particular emphasis on owls is planned. Non-members of the Raptor Research Foundation who wish to receive the preliminary announcement and call for papers should contact Dr. P. B. Hofslund, Biology Department, University of Minnesota, Duluth, Minnesota 55812.

Seventh Trumpeter Swan Society Meeting

The Trumpeter Swan Society will hold its seventh meeting in Victoria, British Columbia, 19–22 February 1981. The Proceedings will be prepublished; authors must have drafts submitted by 15 August 1980, with finished papers returned by 1 November 1980, to meet printing deadlines. Contributors are asked to contact R. McKelvey before 1 July 1980. For further information please contact the Program Chairman **R. McKelvey, Box 340, Delta, British Columbia V4K 3Y3** (Telephone 604-946-8546).

Call for nominations for the Council of The Ottawa Field-Naturalists' Club

A Nominating Committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1981, as required by the Constitution.

Club members may also nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the Nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5, to arrive no later than 15 November 1980.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 1 November 1980. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

ROGER FOXALL,
Chairman, Nominating Committee.

Request for Information — Color-marked Birds

In 1980, the Canadian Wildlife Service will continue a large-scale shorebird banding and color-marking project in James Bay. Since 1974, over 45 700 shorebirds of 27 species have been captured and much information on migration and dispersal routes has been obtained. Observers are asked to look out for and report any color-dyed *or* color-banded shorebirds that they may see. Reports should include details of species, age (if possible), place, date, time, color-marks, and a note of the number of that species present. For color-dyed birds please record the color and area of the bird that was dyed. For color-bands and standard metal leg bands, please record which leg the bands were on, whether they were above or below the 'knee', the colors involved, and the relative position of the bands if more than one was on a leg (e.g. lower right leg, blue over metal etc.). All reports will be acknowledged and should be sent to **Dr. R. I. G. Morrison, Canadian Wildlife Service, 1725 Woodward Drive, Ottawa, Ontario, Canada K1G 3Z7.**

Request for Participants — International Shorebird Surveys, 1980-81

The International Shorebird Survey scheme is organized by the Canadian Wildlife Service and Manomet Bird Observatory to obtain information on shorebird migration and distribution for conservational and research purposes. The scheme was started in 1974 and is providing a continental picture of shorebird distribution through surveys carried out by volunteers in eastern Canada and the USA, the Caribbean Islands, and Central and South America. In 1980, we plan to continue and extend the scheme in as many areas as possible. Any observer who may be able to participate in regular survey counts of shorebirds during spring, autumn and winter periods is asked to contact one of the undersigned. Occasional counts from observers visiting shorebird areas on an irregular basis would also be most welcome. For areas in Canada contact: **Dr. R. I. G. Morrison, Canadian Wilflife Service, 1725 Woodward Drive, Ottawa, Ontario, Canada K1G 3Z7.** For areas in the USA, Caribbean Islands, Central and South America: contact **Brian A. Harrington, Manomet Bird Observatory, Manomet, Massachusetts 02345, USA.**

Book Reviews

ZOOLOGY

Status and Distribution of Alaska Birds

By Brina Kessel and Daniel D. Gibson. 1978. Studies in Avian Biology Number 1, Cooper Ornithological Society (order from James G. Miller, Department of Biology, University of California, Los Angeles, California 90024). iv + 100 pp., illus. U.S. $8.00.

The last comprehensive publication on Alaskan birds was Gabrielson and Lincoln's (1959) *Birds of Alaska*. During the 21 years that have elapsed since they concluded data collection for their work, information on Alaska's avifauna has been accumulating at an increasing rate. Therefore, this review is a welcome and particularly significant addition to the published literature dealing with the birds of Alaska.

Although it is an invaluable compendium of new information, the *Status and distribution of Alaska birds* is not as comprehensive as the title might suggest. Kessel and Gibson treat 202 (53%) of the 381 species recorded in Alaska as of 30 November 1977. Among these are 75 species that have been added to the Alaska avifauna since publication of *Birds of Alaska*, including 30 which are also new to North America. The criteria for inclusion was that the status and distribution of the species "differ substantially" from those described by Gabrielson and Lincoln. For information on the status and distribution of the remaining 179 species one must still consult *Birds of Alaska*. This is unfortunate, since *Birds of Alaska* has long been out of print and many people may not have access to a copy.

The authors have done a remarkable job of collecting, sorting, summarizing, and synthesizing published and unpublished records of Alaska's birds. The bibliography includes 270 references, of which 152 (56%) are post-1955. In addition, the authors have incorporated the unpublished observations of 370 correspondents. The formidable task confronted by Kessel and Gibson is further illustrated by the size of the geographical area treated — more than 2 million square miles, or two-thirds the area of the conterminous United States.

To facilitate the species discussions, the authors have divided the state into six biogeographical regions. The material within the species accounts is generally arranged geographically according to decreasing abundance of the species under discussion. For each species, the authors make generalized statements on status (e.g., "fairly common migrant and breeder," "rare spring migrant," etc.) based on all data available, following which they include "as much specific data as we have felt necessary for substantiation and clarification." The species accounts are brief, ranging from a few lines to about a page in length. For brevity, the authors made liberal use of abbreviations. Although this enables the condensation of a large amount of data into a relatively small space, the extremely telegraphic style makes for difficult reading. Whether for good or bad, this abbreviated style of writing represents a trend in papers dealing with animal distribution, necessitated by increasing publishing costs.

In the case of sight observations of accidental or rare species, or of common species far from their normal range, it would have been helpful to know what type of criteria or review process the records were subjected to before acceptance. For example, the Trumpeter Swan is listed as a "rare breeder" on the coastal plain of eastern northern Alaska, based on four sight observations (three by the same observer) of pairs with young. Hansen et al. (1971. The Trumpeter Swan in Alaska. Wildlife Monographs 26) mapped the known distribution of Trumpeter Swans in Alaska, and determined the theoretical northern limit of the breeding range based on a 145- to 150-day ice-free period. This is the time required for completion of nesting activities, from nest building to fledging of young. Their theoretical northern limit approximates the Arctic Circle, located about 270 miles south of the area in which the observations reported by Kessel and Gibson were made. This is not to say that Trumpeter Swans may not, in fact, be breeding on the North Slope, but I think it illustrates the need for substantiating details. This relatively minor criticism does not detract from the overall excellence and usefulness of the publication. In fairness to the authors, I should point out that of the 202 species treated, at least 193 are documented by specimens or identifiable photographs. For the others, detailed field descriptions are on file at the University of Alaska Museum.

Considering the proliferation of dates and numbers, the text seems remarkably free of errors (this reviewer found none). This is a tribute to the authors' painstaking devotion to detail and accuracy. This work presents an excellent update on the available information on Alaska birds and will make a welcome addition to the libraries of all persons interested in Alaskan birdlife. I highly recommend it.

JOHN L. TRAPP

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Contrasts in Behavior: Adaptations in the Aquatic and Terrestrial Environments

Edited by Ernst S. Reese and Frederick J. Lighter. 1978. Wiley-Interscience, New York. 406 pp., illus. U.S. $27.50.

This book should be used by those interested in comparisons between detailed fish behavior and general terrestrial vertebrate behavior.

Sixteen authors and coauthors, most of them actively engaged in studies of fish behavior, have contributed a total of 12 review chapters based upon their own research. The editors have organized these into four major subjects: reproductive, communicative and regulatory, feeding, and social behaviors. The main treatise is the comparative approach where the systematic, author and subject indexes contribute to making the text a useful reference in this area.

Many passages throughout the text are highly elementary and the reader is left wondering to which educational level the book is geared. The text has a moderate amount of typographical errors (e.g., p. 155). In many spots, the editors have failed to revise highly verbose statements. The chapters that are repetitious, ambiguous, inconsistent and/or incompletely referenced are chapters 3, 6, 8, and 10, those in a mid-section are 1, 2, 7, 9, and 12 and the best chapters are 4, 5, and 11. Any person even vaguely interested in community ecology should read chapter 11, perhaps the best chapter in the book. Chapters are written by George W. Barlow, Thomas L. Beitinger, David Chiszar, Samuel J. Ha, Mireille L. Harmelin-Vivien, Edmund S. Hobson, Miles H. A. Keenleyside, Burney J. Le Boeuf, Paul V. Loiselle, John J. Magnuson, Rudolph J. Miller, Arthur A. Myrberg, Jr., Ernst S. Reese, Peter F. Sale, Ehud Spanier, and Robert R. Warner. The most heavily talked about taxa are the Cichlidae, Labridae, and Pomacentridae. The authors cited most frequently who have not contributed a chapter are: W. H. Neill, D. R. Robertson, C. L. Smith, and E. O. Wilson. The subjects dealt with most often are aggressive, courtship, feeding, and territorial behaviors, competition, and predation.

Conclusions of interest throughout the text include the following. Most fishes with post-hatching parental care breed in unstable waters (chapter 1). Many fishes seem to lek as do some birds, except that in fishes the male is usually left to defend the brood and remains on the lek continuously (chapter 2). Lateral displays in lower vertebrates seem motivationally, functionally, and evolutionarily different from frontal displays (chapter 4). Aggregating behavior in vertebrate prey species seems to decrease the chances of an individual encountering a predator (chapter 7). In both the terrestrial and marine environments, nocturnal carnivores far outnumber the diurnal ones (chapter 8). In general, pinnipeds are more k-selected than terrestrial carnivores (chapter 9). Territorial reef fishes are predominantly interspecifically territorial (chapter 11).

The premise of this book is that the comparative approach is useful when all animals share a common set of problems (i.e., when to breed, where to live, how to obtain enough food, how to avoid predators, etc.). When the same behavioral solutions to these problems are used in very different environments by very different animals, the solutions may be thought of as underlying principles of animal behavior. The editors of this book conclude that lekking, lateral display, acoustical communicative, thermal regulative, territorial, aggregative, and agnostic behaviors should be considered principles of animal behavior in the aquatic and terrestrial environments but parental care and hermaphroditism should not.

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BOTANY

Lichens of the Alaskan Arctic Slope

By John W. Thomson. 1979. University of Toronto Press, Toronto. 314 pp. $35.00.

Anyone having before him the task of identifying lichens from the American Arctic very soon realizes that he is largely "on his own." Descriptions and keys to arctic species of lichens are almost entirely confined to the works of Bernt Lynge, a Norwegian lichenologist who published a number of large and important monographs on the lichens of Greenland and European arctic islands. The important collections made on the Vega expeditions and various forays into the Canadian north by European traders and explorers were never restudied and summarized. On the other hand, over the past 20 years there has been a tremendous surge of interest in the vegetation of the far north, both on the oil-rich arctic slope of Alaska and in the Canadian Arctic. It is into this vacuum that John Thomson has stepped. It did not take him long to see

that it would be impractical to complete a comprehensive monographic treatment in one go. He has therefore produced this volume on the lichens of the Alaskan Arctic Slope as an interim guide until a more complete manual is ready.

Just over 500 species of lichens are described in this book, about a quarter of all arctic species, according to Thomson. The interim nature of the work is evident both from Thomson's introduction (describing the relatively modest amount of field work upon which the flora is based) as well as from the treatment itself. The keys and descriptions are abbreviated, and notes or discussions of the taxa are kept to a minimum. The feeling of working with a compilation of information can be gained from the fact that it is sometimes easy to detect the origin of portions of some keys and descriptions. And so, we have here an attempt to bring together a large quantity of scattered information and make it easier for those dealing with lichens, at least from the western American Arctic, to find names for their specimens.

Although the book succeeds in its task and will be extremely useful, it unfortunately has a number of shortcomings. Some are due to Thomson's personal taxonomic viewpoints and must simply be accepted, but many are due to errors or oversights which might have been avoided.

To me, the most serious problem in the book is that Thomson's "artificial" key is, in many instances, too "natural." I can see no necessity for keying out all genera of lichens in an identification manual. Distinguishing between *Platismatia* and *Cetraria* or *Bryoria* and *Cornicularia*, genera in which the distinguishing features are cryptic and difficult to interpret, would seem to me to be beyond the scope of an identification guide. This confusion between classification and identification may make using Thomson's keys, especially to genera, quite troublesome in places. Even keys to the species of various genera should have included more taxa of different genera that might be confused at the generic level (e.g., *Toninia lobulata* should also appear in the *Bacidia* key, and some *Rhizocarpon* species with brown, one-septate spores might also be keyed under *Buellia* in the same way that the author included *Cornicularia divergens* in the *Bryoria* key).

Many of the so-called segregate genera recognized in recent years are still highly controversial, and it is not surprising that Thomson has not accepted all of them. On the other hand, some of these segregates are firmly established and have solid developmental or morphological bases; I would have expected to see them in a modern lichenological work. Thomson rejects *Micarea, Physconia, Dimelaena,* and *Arthroraphis,* although accepting doubtful genera such as *Blastenia, Omphalodiscus,* and *Agyrophora*. Other genera subsumed by the author include *Aspicilia, Cladina, Huilia, Psora,* and all the recent segregates of *Parmelia*. The Alecterioid genera, I am happy to say, were accepted, as were *Lecidella, Platismatia, Cetrelia,* and *Asahinea*.

Annoying errors have crept into the monograph, undoubtedly in the process of revision and updating. There are several instances of descriptions in the key not agreeing with the text descriptions: *Leciophysma* is keyed out as "foliose" but is described as "granulose to subfruticose"; the phycobiont of *Coriscium* is *Polycoccus* in the key and (correctly) *Coccomyxa* in the text; *Lobaria pseudopulmonaria* is called isidiate in the key, but correctly described as lacking soredia and isidia; several *Lecidella* species are said to be KOH- in the key and KOH+ yellow in the text; *Lecidea flavocaerulescens* keys out as non-sorediate but is later described as "usually sorediate"; *Stereocaulon saxatile* is keyed out as "on earth . . . ," but as its name implies and Thomson states in the text, the species is found exclusively on hard rocks; in the key, *S. paschale* is said to have "granular, flat" cephalodia and in text, the cephalodia are described as "*tuberculose*," whereas in fact, the cephalodia are best described as scabrid, tufted, or granulose.

Some slips which should be pointed out to users of the book include the following: on page 59, the second part of the first couplet goes to #52, not to #3; on p. 172, under *Ochrolechia androgyna*, for "soredia P+ red, read "soredia C+ red"; on p. 173, the last paragraph under *O. androgyna* (beginning, "The very similar . . .") should almost certainly appear under *O. inequatula* instead; on pp. 200–201, "*Ionaspis euplotica*" should be spelled "*I. epulotica*."

Certain descriptive details given by the author should be checked: I doubt that *Lecidella elaeochroma* contains gyrophoric acid; the strong C+ reaction is due to xanthones in the cortex. A recent monograph on *Stereocaulon* states that all *Stereocaulon tomentosum* contains stictic acid; a lobaric acid strain claimed by Thomson on p. 109 is therefore doubtful. *Cladonia cornuta* is keyed out as cupped, but cups are normally quite rare in this species.

I have devoted more space to pointing out problems in the book than I normally might because I believe Thomson's volume will be used as a constant reference for identifying arctic lichens until his full manual is complete. My comments should be thought of as "aids to the user." Certainly, Thomson has done us a great service in making the interim results of his arctic studies available to all of us.

IRWIN M. BRODO

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The Rare Vascular Plants of Nova Scotia

By Robert V. Maher, David J. White, George W. Argus, and Paul A. Keddy. Syllogeus #18. National Museum of Natural Sciences, Ottawa. 1978. 38 pp. Free.

This publication on the rare plants of Nova Scotia is one of a series being done on the Canadian provinces by botanists of the National Museum and associates. Such lists have been prepared for nine of the provinces and can be commented on in advance of publication by naturalists in correspondence with the museum. This list is intended as a guide to which species are in need of protection by law or through the negotiation of ecological reserves, and is part of a worldwide conservation effort by governments co-operating in the Man and the Biosphere project.

As a result, the definition of "rare" has been established at a general level for all provinces. It implies having a small population in that province, whether by reason of a restricted range, few stations, or very small numbers at those stations. A small province like Nova Scotia could expect to have a fairly high proportion of rare species, and indeed 219 taxa are listed (about 214 species) out of not much more than 1000 native species. Yet Ontario has 611 taxa listed as rare in the comparable publication, surely out of less than 3000 species in all? Partly this is the result of a small number of common species and a much larger number of rare ones being the common distribution — the rank/size rule at work. Is it also a case of much greater habitat destruction in Ontario? More likely a reflection of Ontario's greater extent and climatic range.

The rare species of Nova Scotia are automatically "rare in Canada" if found in Nova Scotia alone among the provinces or if rare in those others where it occurs. There are mainly two groups from the extreme ends of the province: the rarer southern outliers of Arctic-coastal or Arctic-montane distribution, notably in northern Cape Breton Island but often scattered on Bay of Fundy cliffs as well, and the many species reaching a northern limit in the mild-winter, maritime southwest tip of Nova Scotia, often species of Coastal Plain affinities. Rare plants of uncommon, usually naturally disturbed sites also occur: those of gypsum, of sea beaches, dunes or other shores. A third large group is made up of the rarer eastern outliers of the hardwood forest flora, and this group, though it includes several of the few species deemed "threatened," seems under-represented in the list. Were the authors unconsciously influenced by the fact that these are not "rare in Canada," or by field experience in the interior of the continent?

As in the Ontario volume, apparently, species not recently collected are regarded as unconfirmed and so excluded. More than in the Ontario list, it seems, though perhaps with justification, North American species of artificially disturbed habitats are excluded, being perhaps regarded as introductions. For instance, some quite distinctive rare sedges are excluded; however, the same exclusion seems to have been applied to a few species of fairly natural habitats. No attention is paid to rare exotic species, though these may remain highly localized rather than invading rapidly. The rare species of the Louisburg area are a case in point.

There are few species whose presence in the list occasions surprise. These are somewhat local and quite conspicuous perennials, likely to be damaged by any picking, which they do invite: notably the Canada Lily and the Purple Trillium (the large White Trillium, of course, does not pass Quebec).

My one complaint is essentially that the list could easily have been longer. Without considering varieties or taxonomically confusing genera, I found about 68 taxa in Roland and Smith's flora which seemed to lie on the borderline between rare and not-rare, and to present as good a case for inclusion or exclusion as many treated in the opposite way by the authors. Even with objectively defined areal criteria, however, there would be room for subjective decision as to whether populations were "small." So, one cannot fault the authors: the slope of the curve is small; arbitrary decisions were called for and were made.

The list does correspond with a Nova Scotian mental list of rare plants pretty closely, and the guidance and co-operation of several resident botanists is acknowledged. Surprises included a notable new Coastal Plain addition, the sundew *Drosera filiformis*, and a few new taxonomies (e.g., the European disposition of our "habenarias" is at last being accepted).

I have raised the point that possibly there has been more habitat destruction in Ontario. This is, of course, due to economic activities such as agriculture and land drainage, forestry, quarrying, power dams, highway and cottage construction. Nova Scotia has been spared some of these in the past by its remoteness from major centers and its relatively small population and large non-agricultural area. But Nova Scotia is much more vulnerable to economic development, which is now going on apace, because it is much smaller and no areas are truly remote from internal economic activities. And most ecological reserves would have to be negotiated with private landowners. Thus, a rapid increase in the number of "threatened species" is conceivable.

D. ERSKINE

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Wild Coffee and Tea Substitutes of Canada

By N. J. Turner and A. F. Szczawinski. 1978. National Museums of Canada, Ottawa. 111 pp. $6.95.

Edible Wild Fruits and Nuts of Canada

By N. J. Turner and A. F. Szczawinski. 1979. National Museums of Canada, Ottawa. 212 pp. $9.95.

These two books are, respectively, volumes Number 2 and 3 in the *Edible Wild Plants of Canada Series* sponsored by the National Museum. Volume Number 1, *Edible garden weeds of Canada*, was published early in 1978 and *Edible wild greens of Canada*, the fourth and final number, is to be published in 1980.

If you are unfamiliar with wild plants but are eager to know and use those valuable for food, then the *Edible Wild Plants of Canada Series* promises to give you all you need except the kitchen sink! *Wild coffee and tea substitutes* and *Edible wild fruits and nuts* both maintain the positive qualities begun with Volume 1 of the series. The authors have combined their technical expertise with a style of writing and organization that is clear and simple. The result is easy and informative reading for anyone. These books will also accent even the most fastidious decor of kitchen or sitting room, as they are artfully designed and colorfully illustrated.

The main body of discussion of species and recipes is printed on odd-sized (approximately 21 × 21 cm) white glossy paper, using a hard black ink in *Wild coffee and tea substitutes,* and a dark brown ink in *Edible wild fruits and nuts.* In the latter book, introductory pages and the index, glossary, etc. are on light walnut-brown paper. In *Wild coffee and tea substitutes,* the use of colored paper (in this case light chestnut brown) is restricted to the index, glossary, and bibliography sections.

Both books contain general introductory discussions of their subjects and note precautions to be observed. Precautions bear repeating whenever the subject of wild edibles is approached: beware of contaminated soils or plants, be certain you have the right plant at the right stage of growth, and begin your use of these unfamiliar foods with moderation. People may have widely differing physical reactions to the same wild plants, and the authors of these books have been careful to point out suspicious or potentially harmful features.

With *Wild coffee and tea substitutes of Canada*, you may come to identify and prepare some 25 species or species groups of wild plants for brewing, including grasses, herbs, trees, and shrubs. There are about 17 recipes for more exotic beverages, besides the individual instructions for brewing each plant. *Edible wild fruits and nuts* deals with 35 species or species groups, with about 120 recipes that will excite the palate (e.g., Arctic raspberry sherbert, cinnamon walnuts, wild plum muffins, — how about may-apple glacé pie!).

All species (or a representative in the case of species groups) are illustrated with either a clear, crisp line drawing or a full-page color photograph. These combine with A. F. Szczawinski's strategic descriptions to give even the beginner a sense of confidence in his plant identifications.

The recipes are well laid out, with both imperial and metric units, and the wire binding of these books allow them to lie flat open at any page. This latter feature is especially valuable to the cook with busy hands and a short memory.

These books (and the series as a whole) have considerably less to offer the backpacker or avid collector of wild edible lore. They are bulky, printed on heavy paper with a peculiar tendency to leave many pages only partly filled with print. I personally feel that most original material presented in the series can be better obtained from the various publications by the authors available from the British Columbia Provincial Museum. These are not only more modest in price and format, but contain more "grass-roots" information. Most of the information presented in the series under review will be available in any personal library on wild edibles that contains five or more volumes. The fact that the books are a series is not taken advantage of, with the result that unnecessary repetition occurs from volume to volume. Thus, for example, several plants fully described and illustrated as edible weeds are again described and illustrated as tea or coffee substitutes, with similar repetition between plants useful as both wild coffee and tea, and with edible fruits or nuts.

Wild coffee and tea substitutes of Canada, and *Edible wild fruits and nuts of Canada* will be at home in well-to-do suburban or rural kitchens, or under the Christmas tree of a budding enthusiast. For others of more modest means, or with a library already stocked with books on this (too often repetitious!) subject, there are many other handier, less expensive texts available, by these and other excellent authors.

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How to Identify Mushrooms to Genus. I: Macroscopic Features; II: Field Identification of Genera; III: Microscopic Features; IV: Keys to Families and Genera

I: by D. L. Largent. 1973. II: by D. L. Largent and H. D. Thiers. 1977. III: by D. L. Largent, D. Johnson, and R. Watling. 1977. IV: by D. E. Stuntz. 1977. 86 pp. US $3.50; 32 pp. US $2.50; 148 pp. US $7.25; and 94 pp. US $4.50 respectively. Mad River Press, Eureka, California.

These four paperback volumes, 14 × 21.5 cm, contain an enormous amount of information. The contents are designed and organized to provide individuals, no matter what their experience, with a means for determining generic names for unidentified mushrooms. The technical nature of the text varies between volumes and within each section of a volume.

The identification of a plant or animal to genus is usually rather simple but this is not the case for many of the Agaricales, i.e., the mushrooms. There is considerable controversy over the circumscription of many genera in the mushrooms. It is not uncommon to find that different authors have placed the same species in different genera. This causes considerable confusion for the non-specialist trying to learn to identify mushrooms. The above volumes provide the reader with a basis for understanding the relationships between genera.

Volumes I and II deal with the gross morphology of the mushrooms, whereas Volumes III and IV incorporate microscopic features as well. The first three parts of Volume I introduce the reader to the mushroom, the numerous terms used to describe its characters, and the life cycle of a fungus which culminates in the formation of the mushroom. Most of Volume I is an illustrated glossary. The illustrations are good quality, technically accurate ink drawings. The terms used to describe each feature are grouped in sections (i.e., terms describing the gills or lamellae are in one section). Part four of Volume I is a key to the genera of mushrooms using only macroscopic features.

Volume II is an annotated list of names for mushroom genera. The purpose is to highlight the principal features that are associated with each genus. Generic relationships are also discussed.

Volume III is a treatment of microscopic features. Initially the study techniques and use of chemical reagents are explained. Sections 4 through 9 present a well-illustrated discussion of mushroom micromorphology (i.e., fungal tissues, hyphae, cystidia, basidia, and spores). Although designed to be used with a microscope this volume is fascinating reading by itself. It will impress upon the mushroom hunters that the microscopic study of specimens, which leads to accurate determinations, is a demanding, highly technical science. Photographs and ink drawings illustrate the intricate, often beautiful, minute cells, especially those in the form of spores. Volume III, like Volume I, devotes considerable space to terminology.

Volume IV is composed to two major sections. One correlates the classical genera ("Friesian genera") of Volume II with the genera that appear in the third edition, 1975, of Singer's classic monograph of the Agaricales. In most instances the Friesian genera have been subdivided and each section is now recognized as a genus of its own. Under each Friesian generic name there is a key that shows the different features of each genus recognized in Singer's book. The second part of Volume IV is a key to the genera accepted in modern classifications. This key relies in large part on microscopic features (e.g., tissue structure, spore shape and ornamentation, etc.).

The volumes emphasize the fundamentals necessary for the study of mushrooms. Only those with a sound background in the fundamentals will grasp the distinctions between allied species and understand why a species is now in the genus *Hydropus* and no longer in *Mycena*. Unfortunately there are places where words or phrases are missing and typographical errors are not rare. In some instances the possibility of misinterpretation exists (e.g., in Volume I on page 15 although the section heading specifies "top view" the term 'conchate' is illustrated by a side view (profile), and Plate 8, B is not a clear representation of the term 'crisped,' nor does the large basidiome in Plate 9, B clearly depict a lateral stipe). Despite these problems, which will, no doubt, be eliminated in future editions, congratulations are due the authors, artists, and the publisher on the production of a needed useable set of books.

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ENVIRONMENT

A Nature Conservation Review

Edited by D. A. Ratcliffe. 1977. Cambridge University Press, London, New York, Melbourne. Volume 1, 401 pp. U.S. $69.50 and U.S. $49.50.

A Nature Conservation Review is defined in a brief Foreword, signed by the Secretaries of State for Environment, and for Education and Science of the United Kingdom, as "An account of the nation's heritage of wildlife and its habitats." It is a two-volume *tour de force* that obviously draws on the expertise and contributions of a great many people, skillfully edited by D. A. Ratcliffe. Authors of chapters are recognized in a list of authors that occupies a whole page, and another page is devoted to acknowledging the varied contributions of others.

Volume Two contains detailed descriptions of "key sites" listed according to seven major formations: Coastlands; Woodlands; Lowland Grasslands, Heaths and Shrubs; Open Waters; Peatlands; Upland Grasslands and Heaths; and Artificial Ecosystems. It will be of interest to only a minority of Canadians, probably in one of two ways: as a model of how to select, arrange, and describe a large number of areas worthy of special consideration, or as a guide to locating areas of special interest during a visit to the United Kingdom.

Volume One, however, contains material of much more general interest. Chapter 2 sets out the rationale of the Review *in extenso* and deals briefly with some methodological problems. Chapter 3 describes the ecological background to site selection. A concluding chapter presents an appraisal and some conclusions. In between there is a chapter devoted to each of the major formations and one chapter each to conservation of flora and of fauna. Since plant communities form the basis for selection of most of the key sites, the chapter on Conservation of Flora is short (6 pages); most of it is devoted to higher plants, including a table showing the number of species of rare plants (in three categories of rarity) either in, or not in, key sites offering a high degree of protection. Overall, 87 of 551 rare plants do not occur in any of the grade 1 and 2 key sites. Bryophytes and lichens get just over one column, and fungi and algae, a single paragraph.

The faunal chapter, in contrast is 25 pages long, more than 14 of which are devoted to birds. Mammals rate about 3 pages, freshwater fish and reptiles and amphibians in total about 2 pages, butterflies and moths more than 2 pages. Weevils, for some reason, are singled out for special attention and there are brief accounts of dragonflies and spiders. Other invertebrate groups were left out in the interest of conserving space! The chapters on conservation of plants and animals serve to show how far behind we are in Canada in the fundamental task of taking an inventory of occurrence of species and in identifying rarities. We now have lists of higher vertebrates and flowering plants, but we have some distance to go in evaluating less conspicuous elements of our fauna and flora.

The long history of biology in the United Kingdom and the small size of the island, of course, means that the "Review" was able to build on a considerable body of pre-existing knowledge. Here again, the contrast with the IBP effort in Canada is striking, since we still have large areas that have seldom, if ever, seen a systematist. It is therefore unexpected, to say the least, to read: "Habitat teams undertook initial field survey to locate sites of importance *in little known districts*" (p. 16, emphasis added), and that "field survey is still incomplete" (p. 2).

The detailed discussion of rationale (basic concepts, assessment and selection of key sites, grading of sites) and methods and results ought to be of universal interest. There are sound discussions of questions with which the Canadian IBP/CT subcommittee also wrestled, and the conclusions reinforce to a considerable degree those reached in Canada.

The set of key areas is meant "to preserve and maintain as part of the nation's natural heritage . . . reservoirs for the main types of community and kinds of wild plants and animals represented in this country." (In Alberta, appeals to the Heritage Savings Trust Fund by the successor to IBP/CT have fallen on deaf ears, suggesting that natural areas with their flora and fauna are not part of our heritage.) In addition to preservation, it was recognized that key sites could provide for research, education, amenity, and aesthetics. In Canada the last two received minor stress, and we put more emphasis on the role of reserved areas as bench marks by which to measure environmental change. In Britain, selection criteria included size (usually small), diversity, naturalness, rarity (of community or component species), fragility, typicalness (really the converse of rarity), recorded history, potential value, and intrinsic appeal. Grading, or ranking, the sites as based on subjective assessment of the best available evidence (something that scientists do all the time, although they seldom admit it).

The accomplishments are summarized in Table 45: 395 grade 1 sites totalling 627100 ha, and 307 grade 2 sites totalling 286300 ha. Altogether this totals 9134 km^2 or about 3528 mi^2. An appendix to Volume One has an index of sites and a series of maps. In

contrast, the most recent directory of Canadian IBP sites contains 1532 entries totalling many thousands of square kilometres, but we have been unable to come close to the wealth of detail available in this review.

A Nature Conservation Review is not bedtime reading (the volumes are too heavy for one thing) and it will appeal to relatively few private biologists, but it deserves a place in every self-respecting university library, and in the public libraries of at least the larger urban centers.

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International Experience with National Parks and Related Reserves

Edited by J. G. Nelson, R. D. Needham, and D. L. Mann. 1978. Department of Geography, University of Waterloo, Waterloo. 624 pp., illus. Paper $10.

For those seeking a broader understanding of national parks and protected areas this is a welcome addition to other publications previously edited in Canada (*Canadian National Parks Today and Tomorrow*, and *Perspectives on Canadian National Parks*). Twenty papers are presented, the majority following a common format suggested by Nelson in his paper on comparative studies. Twelve different countries are treated in depth with a description of the ecology of the country and more specifics on the national parks of particular significance; this is followed by a résumé of the evolution of nature protection which tends to focus on both strategic and institutional arrangements. The latter section deals with legislation, organization, management techniques, perceptions, attitudes and values, and technology. Although the papers are somewhat biased to north temperate climates, the papers on Israel, India, and Nigeria, Colombia, and Costa Rica provide an alternative perspective and emphasize approaches inherent in their traditions in responding to varied cultural and population factors. For instance, the Indians have a strong orientation to wildlife protection whereas Nigeria has traditionally obtained economic returns from forest and game reserves. Israel because of its density of population has chosen to provide a strong recreation orientation to the management of its areas and consequently provides for additional protection through nature reserve legislation for significant natural features. The article on Costa Rica by Mario Bosa and Gilles Lemieux demonstrates a very sophisticated and successful systems approach to the establishment of a park system within a developing country. The positive impact of international organizations such as IUCN and FAO are especially noted in Costa Rica, Colombia, and India.

Reference to the United Kingdom National Parks as the originator of a type of landscape protection which is presently termed "green line parks" in the United States and is commonly referred to as "cultural landscape" in geographic circles is timely because of the increasing flexibility required for natural area protection in settled regions. A quotation noted in Simon's article arising from the Lord Sandford Report (1974) seems to accentuate a principle which requires emphasis on an international scale: "It recognizes explicitly that there will always be irreconcilable conflicts, especially between outdoor recreation and the preservation of the landscape and that in such cases protection should always be given precedence."

Recognizing that landscape preservation is the prime purpose of the national parks in Britain and that they are subsequently quite different in their purpose, function, and administration, the article could have made specific reference to National Nature Reserves which have a specific protection orientation. For instance, in Scotland, nature reserves such as the Carnghorms are in function very similar to the traditional national parks in other countries.

Other papers of a more topical nature explore other types of protection such as protected landscape areas in Norway, the designation of National Tourist Resources and variance in policies governing national park management. This latter issue is of particular interest in examining Norway's system of national parks which is generally considered strict, yet some leniency is evidenced in allowing for herding, fishing, and hunting rights to be maintained in designated areas.

Of interest at the local level and to private organizations with interest in protecting regionally significant resources is an article by Oystein Dalland on the Preservation of Nature and Local Economic Activity — Conflict or Mutual Interest — Norwegian Examples. This article in contrast with many of the others provides detailed legal, financial, and administrative examples of difficulties encountered in a variety of local situations.

The book provides a valuable review of a variety of systems commonly in place throughout the world, increasing our comprehension of the diversity of these areas while no doubt providing some satisfaction with the system we have in Canada. The material is largely factual and objective although some of the figures in the final chapter may be dated (i.e., Canada has 1.3% of the land area in national parks, not 0.8%, which contributed to Canada occupying the 35th spot in

respect to percentages of area in parkland). Another issue is that the map on page 52 shows Gatineau Park as a provincial park, no doubt pleasing Mr. Levesque. One of the typical papers that would be a valuable addition, perhaps when and if another volume is written, would be a series of papers on the concerns, rights, and management techniques appropriate to protected areas where native peoples have traditionally occupied and made use of the natural resources.

For those wishing a comprehensive overview of national parks, the book will provide a ready reference. It also, however, provides for those who may be travelling overseas, background knowledge and guidance on specific areas travellers may wish to visit as well as giving a more holistic view of the overall ecology and natural characteristics of those countries that have been covered.

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Forest Soils: properties and processes

By K. A. Armson. 1977. University of Toronto Press, Toronto. 390 pp., illus. $22.50.

This book aims to provide a comprehensive study of forest soils for foresters, wildlife and park managers, and ecologists, both as an undergraduate introductory text in forest soils and for more advanced programs.

The first ten chapters deal with basic soil information such as physical and chemical properties, soil water, organic matter, soil biology, fertility, soil classification, and surveys. The last six chapters consider the components of the forest soil system as related to processes and the implications of their modification by man.

At the beginning of the book the author seems to be preoccupied with parent material and geological material which he terms "not soil." This is a very awkward term. What if there are no soil horizons and the "not soil" reaches the surface? If this "not soil" supports plant life, why is it not a "soil"? Table 1.1 includes half of the soil horizon suffixes used in the 1974 Canadian system of soil classification. Some of those left out are as commonly used in describing forest soils as are those that are included in this table.

The book provides detailed information concerning the amount and composition of soil organic matter but the classification of forest humus, which is of great interest to foresters and ecologists, is not handled in detail. The section on soil classification provides a good, detailed summary of the United States system. The Canadian system of soil classification, however, is poorly handled and there are inaccuracies in definitions. For example, Armson has transplanted the term "spodic," which is used in the American system, into the Canadian system.

In the soil survey chapter I would expect to see more emphasis on forest soil surveys, indicating those parameters which a forestry-oriented soil survey should have. It is somewhat disturbing that the author gives a fairly detailed example of the Australian land classification system with a two-page diagram. The Canadian ecological (biophysical) land classification system, on the other hand, is discussed only in a short paragraph with just one reference and no examples similar to those provided for the Australian system. Hill's land classification system, which is specifically tailored to surveys of forest land and which is used by foresters in Ontario, is completely ignored. The interpretation of soil surveys is poorly handled in the book. The United States soil capability classification for agriculture is briefly explained but no mention is made of the forestry capability classification used in Canada, especially that used for ARDA and in the Canadian soil survey reports.

The chapters dealing with the components of the forest soil system as related to processes are very informative. The chapters on fire and soil, hydrology, and nutrient cycling are well prepared. They cover the topics well and provide a good cross-section of references from both the United States and Canada. It is unfortunate, however, that the other chapters were not handled so competently. Since the book aims to provide a text for forestry students, presumably including those in Canada, it is important that the Canadian forest soil situation be well represented by examples and references.

The book is relatively free of typographic errors, well-illustrated, and provides general information about forest soils. According to the author, the book has been written with emphasis primarily on North American forest soils. Forest soil books written previously on this continent deal mainly with the forest soils of the southern, temperate regions. This book would have been more useful and valuable if the author had put greater emphasis on giving more examples and references to cover the soils and related problems associated with the northern forest regions of North America.

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MISCELLANEOUS

The Use and Significance of Pesticides in the Environment

By F. L. McEwen and G. R. Stephenson. 1979. John Wiley and Sons, Toronto. 538 pp. $27.50.

This book is derived from a need for a textbook in a course called "Pesticides in the Environment" at the University of Guelph. Very broadly the book attempts to show the risks or ecological consequences and the benefits of pesticides. In many ways it is a digest of selective references in the form of an overview and should equip the student no matter in what area of pesticides he may eventually wish to specialize.

The book contains 21 chapters, 52 pages of references and an alphabetic index by topics. It is up-to-date since most references tend to be cited for periods within the last ten years. The tables and figures which have been re-constructed from other works are simple and easy to read. This textbook comes complete with structural formulae for many of the pesticides. The work is nicely punctuated by descriptions of some rather classical experiments, e.g., ecological residue studies.

Brief descriptions of the majority of pesticides used in North America are effectively covered. The chapter on herbicides is very elaborate in dealing with how they kill plants including basic physiology and biochemical pathways. Also within herbicides there are broad groups which are broken down into smaller headings including chemistry, physiological activity in plants, degradation, effects on non-target organisms, and fate in soil.

Under insecticides, the section on acaricides and miticides is given very little space, e.g., approximately 1–2 pages. Instead I believe that the miticides and acaricides should be more completely cross-referenced to the insecticides. Surprisingly, the more recently discovered halogenated pyrethroids, the insect growth regulators (e.g., Altosid and Dimilin) and synthetic pheromones are hardly mentioned.

The chapter on toxicity tests required for pesticide registration failed to mention neurotoxicity and mutagenic and reproductive tests. It should have also included the role of formulating and therefore diluting the potential hazard of pesticides. The role of pesticides as possible carcinogens, however, is also adequately explored. Chapter 14, Pesticides in Soils, tends to be rather well done. Chapter 15 on pesticides in waters, including both direct and indirect effects, is even more extensive than the chapter on soils. This book shows that pollution levels of pesticides in soils and water are not nearly as bad as environmentalists generally believe. Furthermore, other surveys indicate that there are only extremely low residue levels of pesticides in our food supply. Also included in the chapter on Pesticides and Birds is a rather detailed account of egg-shell thinning. Contamination of birds by pesticide residues is also much lower than expected according to various surveys.

Much of this book deals with the story of DDT, the best understood insecticide within the science of pesticides. One must be cautioned, however, that it is impossible to extend the findings of DDT in the environment to most other pesticides because they do not persist nearly as long.

In conclusion, I enjoyed the very readable style employed by McEwen and Stephenson and believe that the book deserves a place on the shelf of all concerned citizens, pesticide applicators, and legislators interested in gaining a global appreciation of pesticides in the environment. It would not suit a pesticide specialist quite as well.

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NEW TITLES

Zoology

†**The Alaska bird sketches of Olaus Murie.** 1979. Edited by Margaret E. Murie. Alaska Northwest, Edmonds, Washington. 64 pp., illus. U.S. $14.50.

Assignment wildlife. 1980. By Anne LaBastille. Dutton (Canadian distributor Clarke Irwin, Toronto). $13.95.

***Birds of the great plains: breeding species and their distribution.** 1979. By Paul A. Johnsgard. University of Nebraska Press, Lincoln. 546 pp., illus. U.S. $25.

Chironomidae: ecology, systematics, cytology and physiology. 1980. Edited by D. A. Murray. Proceedings of the 7th International Symposium on Chironomidae, Dublin, August 1979. Pergamon Press, New York. 380 pp., illus. U.S. $48.

†**Conservation of marine birds of North America.** 1979. Edited by James C. Bartonek and David N. Nettleship. Wildlife Research Report 11. United States Department of the Interior, Portland, Oregon. 319 pp., illus. Free.

The deer of North America. 1979. By Leonard Lee Rue, III. Crown, New York. xiii +463 pp. U.S. $12.95.

The ecology of arboreal folivores. 1979. By G. G. Montgomery. Smithsonian Institute Press Books, Washington. 574 pp. Paper U.S. $12.50; Cloth U.S. $22.50.

†**Evolutionary biology of parasites.** 1980. Princeton University Press, Princeton. 120 pp., illus. U.S. $15.95.

†**The evolution of culture in animals.** 1980. By John Tyler Bonner. Princeton University Press, Princeton. 225 pp., illus. U.S. $12.50.

Field guide to Australian shells. 1979. By B. R. Wilson and K. Gillet. Reed (Canadian distributor Douglas and McIntyre, Vancouver). 288 pp., illus. $24.

The fishes of Illinois. 1979. By P. W. Smith. University of Illinois Press, Champaign. 314 pp. U.S. $20.

Grazing and riparian/stream crossings. 1979. By O. Cope. Trout Unlimited, Denver. 94 pp. U.S. $3.

How to talk to the birds and the beasts. 1980. By Jacque LeComte and Dorothee Koechlin-Schwartz. Arbor House (Canadian distributor Clarke Irwin, Toronto). $12.95.

The magnificent foragers. 1978. By the Smithsonian Institution. Norton, New York. 223 pp. U.S. $16.95.

Marine mammals. 1980. Edited by Delphine Haley. Pacific Search Press (Canadian distributor Douglas and McIntyre, Vancouver). 256 pp., illus. Paper $22.95.

Marine mammals of the world. Volume 1, Whales, dolphins and porpoises. Volume 2, Seals, sea lions, otters and sea cows. 1980. By Stephen Heatherwood, Bruce R. Maté, and Randall R. Reeves. Painter-Hopkins (Canadian distributor Clarke Irwin, Toronto). $57.97 each.

The Mediterranean monk seal. 1979. Edited by K. Ronald and R. Duguy. Proceedings of a conference, Rhodes, Greece, May 1978. Pergamon Press, New York. 250 pp., illus. U.S. $32.

Migration of birds. 1979. By C. F. Lincoln. Revised edition by S. R. Paterson. Circular 16. United States Fish and Wildlife Service, Washington. 119 pp.

The nesting season: the bird photographs of Frederick Kent Truslow. 1979. By H C. Cruickshank. Viking Press, New York. 136 pp. U.S. $30.

†**The Ordovician trilobite *Pseudogygites* Kobayashi in eastern and arctic North America.** 1979. By Rolf Ludvigsen. Life Sciences Contributions 120. Royal Ontario Museum, Toronto. 41 pp. $3.

Owls. 1980. By Tony Angell. Douglas and McIntyre, Vancouver. 80 pp., illus. Paper $8.95.

Pacific salmon. 1979. By R. J. Childerhose and M. Trim. University of Washington Press, Seattle. 160 pp. U.S. $25.95.

Pacific salmon and steelhead trout. 1979. By R. J. Childerhose and Marj Trim. Supply and Services Canada, Ottawa. 158 pp., illus. $25.95 in Canada; $30 elsewhere.

Predator-prey systems in fisheries management. 1979. By H. Clepper. Sport Fishing Institute, Washington. 504 pp. U.S. $20.

Reptiles and amphibians of Australia. 1979. By H. G. Cogger. Reed (Canadian distributor Douglas and McIntyre, Vancouver). 608 pp., illus. $48.

Social insects. 1979. Edited by Henry R. Herman. Academic Press, New York. xvi + 438 pp., illus. U.S. $36.

Songbirds in your garden. 1980. By John K. Terres. 3rd edition. Hawthorn (Canadian distributor Clarke Irwin, Toronto). $8.95.

Status and distribution of Alaska birds. 1978. By Brina Kessel and Daniel G. Gibson. Studies in Avian Biology Number 1, Cooper Ornithological Society, c/o James G. Miller, Department of Biology, University of California, Los Angeles. iv + 100 pp., illus. U.S. $8.

Surveys of tidal river systems in the Northern Territory and their crocodile populations. Monograph Number 2: the Victoria and FitzMaurice River Systems. 1979. By H. Messel et al. Pergamon Press, New York. 52 pp., illus. U.S. $16.

The technical literature on the American woodcock 1927–1978. 1979. By T. J. Dwyer, R.A. Coon, and P. H. Geissler. Special Scientific Report, Wildlife Number 213. United States Fish and Wildlife Service, Washington. 44 pp.

Time in animal behaviour. 1980. By M. Richelle and H. Lejeune. Pergamon Press, New York. 256 pp., illus. Cloth U.S. $30; paper U.S. $19.

Turtles: perspectives and research. 1979. Edited by Marion Harless and Henry Morlock. Wiley-Interscience, New York. xvi + 696 pp., illus. U.S. $45.

The warblers of America. 1979. Edited by L. Griscom and A. Sprunt, Jr. Revised by E. M. Reilly, Jr. Doubleday, New York. 302 pp. U.S. $19.95.

Botany

The algae of southern Victorialand, Antarctica: a taxonomic and distributional study. 1979. By K. G. Seaburg, B. C. Parker, G. W. Prescott, and L. A. Whitford. Bibliotheca Phycologica 46. Cramer, Braunschweig. 170 pp., illus. DM50.

The alpine flora of New Guinea. Volume 1, general part. 1979. **Volume 2, taxonomic part 1: Cupressaceae to Poaceae.** 1979. **Volume 3, taxonomic part 2: Winteraceae to Polygonaceae.** 1980. **Volume 4, taxonomic part 3: Fagaceae to Asteraceae.** 1981. Edited by P. Van Royen. Cramer, Braunschweig, West Germany. 318 pp., illus; 1232 pp., illus; 800 pp., illus; 800 pp., illus., respectively. Set DM800.

†**Budd's flora of the Canadian prairie provinces.** 1979. By J. Looman and K. F. Best. Agriculture Canada, Ottawa, Publication 1662. 863 pp., illus. $8.50 in Canada; $10.20 elsewhere.

Diatoms in New Zealand: the North Island. 1979. by N. Foged. Bibliotheca Phycologica 47. Cramer, Braunschweig, West Germany. 226 pp., illus. DM60.

Edible and poisonous mushrooms of Canada. 1979. by J. Walton Groves. Revised edition. Agriculture Canada, Ottawa, Publication 1112. 326 pp., illus. $9.95 in Canada; $11.95 elsewhere.

Endangered and threatened plants of the United States. 1979. By E. S. Ayensu and R. A. DeFilipps. Smithsonian Institute Press Books, Washington. 403 pp. U.S. $17.50.

Fifth symposium on recent and fossil diatoms, Antwerp, September, 1978. 1979. Edited by R. Simonsen. Cramer, Braunschweig, West Germany. 532 pp., illus. DM200.

The marine algae of New Zealand. Part III: Rhodophyceae. Issue 4: Florideophycidae: Gigartinales. 1979. By V. J. Chapman. Cramer, Braunschweig, West Germany. Pp. 279–510, illus. DM80.

A monograph of Ramaria subgenus Echinoramaria. 1980. By R. H. Petersen. Cramer, Braunschweig, West Germany. 150 pp., illus. DM60.

Perspectives in grassland ecology. 1979. Edited by N. R. French. Springer-Verlag, New York. 190 pp. U.S. $22.80.

Plankton and productivity in the oceans. Volume 1, phytoplankton. 1980. By J. E. G. Raymont. 2nd edition. Pergamon Press, New York. 450 pp., illus. Cloth U.S. $50; paper U.S. $20.

The tropical grasses of southeast Asia (excluding bamboos). 1980. By M. Lazarides. Phanerogamarum Monographiae xii. Cramer, Braunschweig, West Germany. 350 pp. DM80.

Variation and evolution of the nearctic harebells (Campanula subsection Heterophylla). 1980. By St. G. Shetler. Phanerogamarum Monographiae xi. Cramer, Braunschweig, West Germany. 480 pp., illus. DM150.

Vegetation of the earth. 1979. By Heinrich Walter. Springer-Verlag, Secaucus, New Jersey. 274 pp., illus. Paper U.S. $13.90.

Environment

The beaches are moving: the drowning of America's shoreline. 1979. By W. Kaufman and O. Pilkey. Doubleday, New York. 336 pp. U.S. $10.95.

†**Biogeography.** 1979. By E. C. Pielou. Wiley, Somerset, New Jersey. 351 pp., illus. U.S. $22.50.

Canada's special resource lands: a national perspective of selected land uses. 1979. By Wendy Simpson-Lewis et al. Lands Directorate Map Folio 4, Supply and Services Canada, Ottawa. 232 pp., illus. $12 in Canada; $14.40 elsewhere.

†**Conservation biology: an evolutionary-ecological perspective.** 1980. Edited by Michael E. Soulé and Bruce A. Wilcox. Sinauer, Sunderland, Massachusetts. xv + 395 pp., illus. Paper U.S. $14.95.

The effects of weapons on ecosystems. 1979. By J. P. Robinson. Pergamon Press, New York. 76 pp. U.S. $14.

Environmental impact of energy strategies within the EEC. 1980. Edited by Environmental Resources Limited. Pergamon Press, New York. U.S. $22.

Environmental protection in frontier regions. 1979. By Anonymous. OECD (Canadian distributor Renouf, Toronto). 504 pp. $24.

Environmental value in public decisions — a research agenda. 1979. By R. N. L. Andrews and M. J. Waits. National Technical Information Service, Springfield, Virginia. 91 pp. U.S. $6 (plus 25% foreign handling).

Environment and development in Africa. 1980. Edited by the United Nations Environment Programme and the Environment Training Programme. Pergamon Press, New York. 100 pp., illus. U.S. $14.

Footprints on the planet: a search for an environmental ethic. 1978. By R. Cahn. Universe Books, New York. 253 pp. U.S. $10.95.

Guide to the National Wildlife Refuges. 1979. By L. and W. Riley. Doubleday, New York. 672 pp. U.S. $14.95.

The heyday of natural history. 1980. By Lynn Barber. Cape (Canadian distributor Clarke Irwin, Toronto). $32.95.

Nature alive. 1980. By Colette Portal. Chatto and Windus (Canadian distributor Clarke Irwin, Toronto). $11.95.

Off-road vehicles on public lands. 1979. By D. Sheridan. Council on Environmental Quality, Washington. 84 pp.

103 hikes in southwestern British Columbia. 1980. By David and Mary Macaree. Revised edition. Douglas and McIntyre, Vancouver. 240 pp., illus. Paper $8.95.

Poisons in public: case studies of environmental pollution in Canada. 1980. By Ross Howard. Lorimer, Toronto. 224 pp. Cloth $15; paper $8.95.

Proceedings: land use planning workshop. 1979. Edited by D. L. Erickson. United States Forestry Service, Broomall, Pennsylvania. 138 pp. U.S. $5.

Progress in resource management and environmental planning. 1979. By Timothy O'Riordan and Ralph C. D'Arge. Wiley, Somerset, New Jersey. 320 pp. U.S. $38.50.

†**Recreational land use in southern Ontario.** 1979. Edited by Geoffrey Wall. Department of Geography Publication Series Number 14, University of Waterloo, Waterloo. 376 pp., illus.

Renewable resources in our future. 1980. By A. D. Hinckley. Pergamon Press, New York. 120 pp., illus. Cloth U.S. $14; paper U.S. $7.

Resources, society and the future. 1980. By the Secretariat for Future Studies, Stockholm. Pergamon Press, New York. 250 pp., illus. Cloth U.S. $30; paper U.S. $15.

Theoretical systems ecology: advances and case studies. 1979. By E. Halfon. Academic Press, New York. 544 pp. U.S. $3.

The tidemarsh guide. 1979. By M. F. Roberts. Dutton, New York. 256 pp. $7.95.

Trees, shrubs and vines for attracting birds: a manual for the northeast. 1979. By R. M. DeGraff and G. M. Witman. University of Massachusetts Press, Amherst. 256 pp. U.S. $12.50.

The West Coast Trail and Nitinat Lakes: a trail guide. 1980. By the Sierra Club of British Columbia. Douglas and McIntyre, Vancouver. 96 pp., illus. Paper $5.95.

Miscellaneous

†**Agriculture in semi-arid environments.** 1979. Edited by A. E. Hall, G. H. Canell, and H. W. Lawton. Springer-Verlag, New York. 340 pp., illus. U.S. $49.80.

Careers in conservation. 1979. Edited by H. Clepper. Wiley, New York. 180 pp.

"Ding" the life of Jay Norwood Darling. 1979. By David L. Lendt. Iowa State University Press, Ames. ix + 202 pp., illus. U.S. $9.95.

Directory of institutions and individuals active in environmentally-sound and appropriate technologies. 1979. Edited by the United Nations Environmental Programme. Pergamon Press, New York. 120 pp. U.S. $27.50.

Douglas of the forests: the North American journals of David Douglas. 1980. By John Davies. University of Washington Press (Canadian distributor Douglas and McIntyre, Vancouver). 176 pp., illus. $14.95.

Energy aspects of the forest industries. 1979. Edited by the United Nations Economic Commission for Europe. Proceedings of a Seminar, Udine, Italy, November 1978. Pergamon Press, New York. 428 pp., illus U.S. $54.

How to write and publish a scientific paper. 1979. By R. A. Day. I.S.I. Press, Philadelphia. xi + 160 pp. U.S. $8.95.

The ozone layer. 1979. Edited by A. K. Biswas. Pergamon Press, New York. 374 pp., illus. U.S. $50.

Solar energy conversion: an introductory course. 1979. Edited by A. E. Dixon and J. D. Leslie. Pergamon Press, New York. 1200 pp., illus. U.S. $60.

Solar versus nuclear: choosing energy futures. 1980. By the Secretariat for Future Studies, Stockholm. Pergamon Press, New York. 250 pp., illus. Cloth U.S. $30; paper U.S. $15.

Time lags in biological models. 1979. By N. Macdonald. Springer-Verlag, New York. vii + 112 pp. Paper U.S. $9.95.

* Assigned for review.
† Available for review.

Minutes of the One Hundredth Annual Business Meeting of The Ottawa Field-Naturalists' Club

The 100th Annual Business Meeting of The Ottawa Field-Naturalists' Club was held in the auditorium of the National Museum of Natural Sciences on 9 January 1979. The President, Dr. R. A. Foxall, called the meeting to order at 8:13 p.m., with a quorum of 41 persons present (final total 43). The Recording Secretary read the minutes of the 99th Annual Meeting, which were amended and approved on motion (by W. Cody, 2nd G. J. Wasteneys).

R. Foxall referred to business arising from the minutes. The last meeting of the Council had decided that one auditor, not two, was sufficient. The change to one auditor will require a change to the Constitution, and will have to come before the next Annual Meeting. Mr. and Mrs. Hugh Munro have decided to give up looking after the Moodie Drive feeder, after about 10 years of dedicated effort; the Club is most grateful to them. A replacement has been hard to find, as this is a twice-a-week job; it is currently being done on a rotating basis, one month at a time.

R. Foxall read out a letter from D. H. Baker, who had 150 young black walnut trees to dispose of, and was offering them to Club members willing to dig their own; this offer is to be advertised in *Trail & Landscape*. R. Taylor then pointed out some errors in the listing of forthcoming excursions in *Trail & Landscape*.

The audited financial statement was presented to the meeting by the Club Treasurer, B. Henson. It was noted that honoraria come out of *The Canadian Field-Naturalist*'s operating expenses for the Editor, Business Manager, and Production Manager of that journal; honoraria were paid out of the Club's operations budget for the Editor and Business Manager of *Trail & Landscape*, and for the accountant in 1976 and 1977. D. A. Smith noted that the Publications Committee has a budget but that no expenses were listed; K. Strang, the Chairman of that committee, stated that this was correct, as his first bill for expenses had been submitted after the end of the fiscal year. E. Dickson moved (2nd K. Strang) adoption of the 1977–78 financial report; the motion was approved.

The Annual Report of Council, to be published in *The Canadian Field-Naturalist*, was read by R. Foxall. D. A. Smith questioned the discrepancy between the amount of the National Research Council grant as reported therein, and as listed in the financial report; B. Henson replied that it was due to the grant being a lump sum given for a calendar year, but having to be accounted for over a financial year. In answer to an informal poll by R. Foxall, it appeared that none of those present had noticed the advertisements for the monthly meetings in the local papers. D. A. Smith requested that writers of committee reports follow the edited and published reports, and not use initials and short forms, as these have to be edited to their correct form, making extra work for the Editor. Acceptance of the report, after some editorial amendments, was moved by J. Reddoch, 2nd P. Narraway, and approved.

R. Foxall then called on E. Todd, as Chairman of the Nominating Committee, to present the slate. Todd said that the committee had included I. Brodo and E. Dickson, as well as himself; and that two of the nominations had been received from the membership at large. He then presented the slate:

President: R. Taylor; Vice-President: C. Gilliatt; Treasurer: B. Henson; Recording Secretary: D. Laubitz; Corresponding Secretary: V. Hume; Past President: R. Foxall; additional members of Council: E. Beaubien, C. Beddoe, R. Bedford, F. Bell, W. Cody, J. Diceman, E. Dickson, L. Dickson, M. Forget, F. Goodspeed, P. Hall, H. MacKenzie, F. Pope, I. Sneddon, K. Strang, K. Taylor, E. Todd.

On motion (by E. Todd, 2nd L. Howden) the proposed slate was approved. R. Foxall, on behalf of the Club, and of himself as Chairman of Council, thanked those Councillors who were retiring, or who had retired during the year, for their help and support: Albert Dugal, Chuck Gruchy, Jeff Harrison, Jo Ann Murray, Marsh Ney, Gilles Patenaude, and Stan Teeple.

The Auditors for 1978–79, M. Brigham and G. J. Wasteneys, were approved on motion (by R. Taylor, 2nd W. Cody).

A motion to amend the Constitution of The Ottawa Field-Naturalists' Club, previously published in *The Canadian Field-Naturalist* in accordance with Article 23 of the Constitution, was read out to the meeting by R. Taylor. He explained that the change was being proposed for the sake of consistency. All other Club fees are covered by the By-laws, and any changes to the fee structure are more easily implemented by amendments to the By-laws than by changes to the Constitution. E. Todd recommended that any proposed change in the Life Membership fee should be advertised before coming into effect; however, both R. Taylor and R. Foxall suggested that this might be against the Club's interests. P. Narraway questioned the category of Benefactor in the Constitution; this is by nature a donor rather than a fee payer, and it is not considered necessary to make changes in this category. The motion was carried, thus amending the constitution.

R. Foxall expressed his personal thanks to Roger Taylor who, as hard working Vice-President and Chairman of the Finance Committee, has, with Barry Henson, brought our financial practices to their current efficient state; to Hue MacKenzie for the enormous amount of work that he has done on the Centennial Steering Committee; to Bill Cody, for his vast store of knowledge of Council matters and practices; to all the members of the Conservation Committee, for their efforts in 1978 on our behalf, in the knowledge that if we succeed in our efforts it will be owing to their work, and if we fail we can in no way fault them. Foxall also thanked the Recording Secretary, Diana Laubitz, for her support and stern eye on the Constitution, at Council meetings; those who work behind the scenes, our coffee ladies, Monica Birt, Mona Coleman, Eileen Evans, Helen Tweedie, and Alice Weddall; and all Club members for their support of him during his Presidency.

R. Taylor expressed his thanks to R. Foxall for all the hard work, and time and effort, that he has expended on behalf of the Club.

After the introduction of those members of the new Council who were in attendance, adjournment of the meeting was moved by K. Strang, 2nd V. Hume, at 9:40 p.m.

A long social hour, during which refreshments were served, allowed members to meet one another and to ask any questions that they may have had about the functioning of the Club.

D. R. LAUBITZ, Recording Secretary

Report of Council to The Ottawa Field-Naturalists' Club

Our Centennial this year has focussed the attention of Council on the fact that much of the material held by Council and Club members is of historical importance. A visit to the Council meeting of 5 November by Normal Ball, Science and Engineering Archivist at the Public Archives, was arranged by Joyce Reddoch. Mr. Ball explained to Council the nature and importance of archival material, and emphasized his interest in all our papers; what may seem unimportant from the point of view of the Club may be of interest because of the other subjects that it illuminates. Material for the Public Archives will be picked up, and even packed if necessary; it will be indexed and properly cared for; and nothing will be destroyed without the express permission of the donor.

Centennial year represented the culmination of four years work by the *Centennial Steering Committee*. During the year the following projects were accomplished: Club pin, Centennial dinner, exhibit at the National Museum of Natural Sciences, Centennial conference, Centennial picnic, Macoun Club natural history trail, 'Songs of the Seasons' stereo record, hasti-notes, Centennial birthday party, new bird checklist for Ottawa, Centennial calendar. Few Club members can have any idea how much effort was put into these activities so that all of us could enjoy the results; on behalf of all members of the Club we thank the many individuals who made all of the above successful. Some of our Centennial projects are still to be completed; well advanced and with completion dates within the next few months are Macoun's autobiography, reprinted and enhanced; indices to the forerunners of *The Canadian Field-Naturalist;* and 'Orchids in the Ottawa District.' In addition, the Club is undertaking the publication of a natural history Guide to the Ottawa area, a longer-term project that will probably be several years in preparation. Two of our proposed Centennial projects unfortunately did not come to pass; we had hoped to arrange for the issue of a postage stamp on a subject associated with our 100 years of activity, but found that this was contrary to the Post Office policy. Council also approved the preparation of a report on bird observations in our area in 1979; regrettably, no one has yet volunteered to undertake this work, although the data sheets for the year have been retained by the Bird Records Committee in the hope that an author may still be forthcoming. The final report of the Centennial Steering Committee will be presented to Council within the next few months.

(Hue MacKenzie)

Finance Committee: the 1978–79 budget was adopted by Council in December 1978; the financial statement for this same year was ready for auditing early in November 1979. An amendment to the Constitution, reducing the number of auditors from two to one, was moved and is to be put before the Annual Business Meeting. Ron Bedford was appointed by Council to maintain an inventory of all salable items, excluding back issues of our publications. Council approved a request by the Treasurer for a bookkeeping assistant, and his suggestion that this work be done by the Assistant to the Treasurer, whose statement of duties and annual stipend will be revised accordingly. The Committee recommends that, in view of the rather large holding of capital by the Club, suitable projects for the expenditure of some of these funds should be sought.

(C. Gilliatt)

Membership	Canadian (local)	Canadian (other)	USA	Foreign	Totals
Individual	455 (454)	339 (321)	96 (102)	3 (3)	893 (880)
Family	219 (198)	29 (26)	1 (1)	1 (2)	250 (227)
Sustaining	15 (9)	1 (–)	nil	nil	16 (9)
Life	12 (13)	12 (7)	3 (3)	2 (2)	29 (25)
Honorary	6 (5)	4 (4)	nil	nil	10 (9)
Totals	707 (679)	385 (358)	100 (106)	6 (7)	1198 (1150)
Changes	+28	+27	–6	–1	+48

Figures in brackets represent 1978.

The *Membership Committee* reported that the total Club membership now stands at 1198 compared with 1150 in 1978; membership structures is as shown in table above. In its Centennial year the Club was proud to name four new Honorary Members: W. J. Cody, C. D. H. Clarke, George McGee, and Pauline Snure. In the same year, however, the Club lost three well known Honorary Members: W. A. Squires, F. E. Banim, and W. K. W. Baldwin. A proposal that names of new members be listed in *Trail & Landscape* was adopted. I thank the members of this committee, as they contributed to notifying members of required membership renewals, mailing out membership cards, maintaining membership records, seeing to preparation of *Trail & Landscape* labels, and providing new members with the Club information package.

(Frances E. Goodspeed)

The *Publications Committee* reported that in 1979 *The Canadian Field-Naturalist* was published in five issues, Volume 92(4) and Volume 93 (1, 2, 3, 4) with a total of 599 pages containing 41 articles, 62 notes, 20 book reviews, and a list of 409 new book titles of interest to naturalists. No scientific publication grant was required in 1979, and the financial position for 1980 is strong enough to carry out our publication plans without a grant. *Trail & Landscape* was published in five issues (Volume 13) containing 184 pages of Club activities and articles on the natural history of the Ottawa area. After 13 years of dedication, Anne Hanes has decided not to seek reappointment as Editor; I am confident that all members will join me in thanking Anne for her untiring efforts over the years. Joyce Reddoch has been appointed Editor for 1980. *The Shrike* was published in eight issues containing news of interest to local birders; Bruce Barrett, the Editor, has heeded the siren call of California, and the future of *The Shrike* is uncertain. Again I am confident that all will join me in thanking Bruce for the creation and publication of this journal. The committee is also involved in coordinating two Centennial projects: *The Autobiography of John Macoun*, originally published by the Club in 1922 as a memorial volume, is being reissued with an introduction by R. Glover, editorial notes, and a biographical essay; and the *Index to Transactions of The Ottawa Field-Naturalists' Club and The Ottawa Naturalist*, is currently being edited, and a grant of $4500 has been received from the Natural Sciences and Engineering Research Council to help defray publication costs.

(J. K. Strang)

In this Centennial year, much extra effort was required from the members of the relatively small *Excursions and Lectures Committee*. The main events comprised the Birthday Party, held in the salon of the National Museum of Natural Sciences, with our oldest past President, Charles Sternberg, as guest of honor; the Centennial Weekend, with its four field trips and the Banquet; and the Centennial Picnic, planned around six field trips. Seven monthly meetings with an average attendance of about 60 were held in the auditorium of the National Museum of Natural Sciences, and a members slide night in the more informal Activity Center at the Museum was most successful. The 43 excursions organized during the year included a joint hike with the Ottawa Rideau Trail Club, a visit to the National Insect Collection, and an evening of astronomy at the National Museum of Science and Technology. The eight bus trips were effectively arranged by David Bewley, and continue to be popular. The committee is grateful to all speakers and trip leaders, and to all who helped during the year, particularly Louis Lemieux for the cooperation and facilities that he and his staff at the National Museum of Natural Sciences continue to provide to the Club; I also thank all of the committee members for their excellent and hard work.

(Charlie Beddoe)

Conservation lands in the Ottawa-Carleton Region continued to dominate the activities of the *Conservation Committee* in 1979. Most of the effort was directed to support of the natural environment areas

approved by the Planning Department of the Regional Municipality; the thrust of our activities was to keep what was already on the tentatively approved plan, but the input of politicians, many of them influenced by landowners, meant that compromises were going to be made. The amendments to the Official Plan have recently been approved by the Regional Council, and the majority of the areas that the Club supported have been included in the Plan. One other area of influence that the committee thought worth pursuing was consultation with the District Office, Ontario Ministry of Natural Resources, in regard to management of areas that included sites of specific interest; time will tell whether this approach will prove useful. Considerable correspondence regarding planning and maintenance of areas managed by the Ministry of Natural Resources was exchanged by the Minister, and representatives of the Club and the Federation of Ontario Naturalists, the main point being the direction of policies for managing plants and animals that do not have a measurable monetary return. The Ottawa and Rideau River Shores Study by the Regional Municipality was examined by the committee, and input was made to the Planning Department for the inclusion of Morris Island and Buckham's Bay in the natural environment areas; field trips were conducted to help prepare submissions, and comment was made on the value of specific fish spawning, waterfowl, and geological sites. Limited input has been made into a study of an area northwest of Kanata, to determine the impact on the environment of three proposed roads. The Committee contributed to the Centennial exhibit with a display on conservation, showing the impact of development in the local area over 100 years. It is with pleasure that we acknowledge Joyce Reddoch's contribution to conservation with her receipt of the Murray Boegel Conservation Award presented by the Ottawa Fish and Game Association.

(E. C. D. Todd)

The *Macoun Field Club* has had another successful year despite the resignation of David Gray as Chairman of the Senior group; Elisabeth Beaubien, Fazal Mohammed, and Peter Hall offered to assist in this role, and Arnet Shepard continues as Chairman of the Club. The Seniors have been extremely active this year; the Centennial Nature Trail has now been completed; this year's symposium, entitled 'Another Way,' dealt with topics concerning energy conservation and environmental problems; field trips included a nine-day canoe trip, an excursion to St. Lawrence Islands National Park, and a trip to the Raptor Centre in Montreal. The Juniors and Intermediates have been to the Montreal Aquarium, to Kingsmere in the Gatineau Park, to the Carleton University greenhouses, and to the Ichthyology Section of the National Museum of Natural Sciences. Access to the Dinobus, which is run by the Museum, has been of major importance to the Club, solving the transportation problems which previously faced the chairmen prior to any trip; once again we are deeply indebted to the Museum.

(H. L. Dickson)

In terms of education, the activities of the *Education and Publicity Committee* were quite varied, ranging from writing to a very young lady on 'how to become a naturalist' to finding a speaker to talk to the RA Ski Club on the 'Environmental Aspects of Cross-country Skiing.' The Bytown Museum was supplied with photographs of early Club activities for a historical exhibit. A letter was distributed to local schools advertising the availability of *Trail & Landscape,* but produced very little result. Publicity needs of our Centennial kept us busy this year; the local media were invited to the birthday party, resulting in some interesting newspaper articles. I thank the members of the committee, especially Peter Hall and Ken Taylor, for all their hard work this year.

(Elisabeth Beaubien)

The Ad Hoc Committee on Publications has just been set up, under the chairmanship of Roger Foxall, and is to report to Council by June 1980. One of our publications, *The Canadian Field-Naturalist*, was the reason for the Club's receiving a conservation award from the Federation of Ontario Naturalists, for its continued excellence and for acting as a forum for publication by both professionals and amateurs. The Centennial Seminar papers are being prepared for possible publication in this journal.

Council members were invited to the launching of the endangered species stamps, and the President accepted, on behalf of the Club, a presentation set of whale and turtle stamps.

Compiled from committee reports and Council munutes by D. R. LAUBITZ, Recording Secretary

Auditors' Report

To: Members of The Ottawa Field-Naturalists' Club

We have examined the balance sheet of The Ottawa Field-Naturalists' Club as at September 30, 1979, and the related Income Statements for the year then ended. Our examination included a general review of the accounting procedures and such tests of the records and supporting vouchers as considered necessary under the circumstances.

In our opinion these financial statements present fairly the financial position of the organization as at September 30, 1979 and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

(Signed) Geoffrey Wastenays

December 21, 1979 F. Montgomery Brigham

The Ottawa Field-Naturalists' Club Balance Sheet

as at September 30, 1979

Assets

Current			
Cash and term deposits		$66,545.00	
Accounts receivable		2,833.14	
Accrued interest		1,495.35	
Prepaid expenses		790.65	$71,664.14
Fixed at cost			
Equipment		529.50	
Less accumulated depreciation		454.00	75.50
Total Assets			$71,739.64

Liabilities and Surplus

Current liabilities			
Accounts payable		$1,226.26	
NSERC[1]		4,500.00	
Deferred income		7,110.39	$12,836.65
Surplus			
Balance October 1, 1978		55,569.75	
Add: income over expenditure			
The Ottawa Field-Naturalists' Club	$2,747.05		
The Canadian Field-Naturalist	6,146.33		
	8,893.38		
Less: net expenditure — Centennial projects	5,560.14	3,333.24	
Balance September 30, 1979			58,902.99
Total liabilities and surplus			$71,739.64

[1]Natural Sciences and Engineering Research Council grant for an Index to the *Transactions of The Ottawa Field-Naturalists' Club* and *The Ottawa Naturalist.*

The Ottawa Field-Naturalists' Club
Statement of Income and Expenditure

for the year ended September 30, 1979

Income			
Apportionment of membership fees			
Annual	$7,170.92		
Life	480.00	$7,650.92	
Trail & Landscape			
Subscriptions	200.00		
Back numbers	15.19	215.19	
Shrike subscriptions		499.00	
Sales — decals, emblems		13.75	
		8,378.86	
Interest		3,133.23	$11,512.09
Expenditure			
Trail & Landscape			
Publishing	$ 4,078.96		
Circulation	167.76		
Editing and office	219.37		
Honoraria	275.00	$4,741.09	
Shrike publishing & expenses		376.58	
Committee activities — net			
Excursions & lectures	128.08		
Membership	982.38		
Macoun Club	130.44		
Conservation	101.76		
Bird records	46.64		
Bird feeders	586.20		
Publications	7.00		
Education	11.30		
Orchid survey	8.01	2,001.81	
Baldwin scholarship	150.00		
Special activities	380.55		
Council expenses	358.50		
Office supplies	681.90		
Miscellaneous	74.61	1,645.56	8,765.04
Excess of income over expenditure			$ 2,747.05

The Ottawa Field-Naturalists' Club
Statement of Centennial Project Expenditures

for the year ended September 30, 1979

Recording — Songs of the seasons		
Expenditure	$5,919.22	
Revenue	4,025.54	$1,893.68
1979 calendar		
Expenditure	1,405.32	
Revenue	150.00	1,255.32
Club pin		
Expenditure	1,188.36	
Revenue	159.60	1,028.76
Bird record cards		
Expenditure	405.95	
Revenue	78.75	327.20
Hasti-notes		
Expenditure	89.07	
Revenue	58.80	30.27
Macoun autobiography reprint		518.46
Exhibition		692.65
Seminars/weekend celebration		248.61
Birthday party		185.88
Nature trail		4.25
Picnic		202.78
		6,387.86
Less donations		827.72
Net expenditure		$5,560.14

The Ottawa Field-Naturalists' Club
Statement of Income and Expenditure — *The Canadian Field-Naturalist*

for the year ended September 30, 1979

Income			
Apportionment of membership fees			
Annual	$ 4,780.61		
Life	320.00		
	5,100.61		
Subscriptions	15,328.45	$20,429.06	
Publication			
Reprints	6,860.40		
Plates & tab settings	1,902.50		
Extra pages	9,167.00		
Back numbers	1,037.06	18,966.96	
Grant		550.00	
Other — interest	4,309.13		
exchange	1,341.11	5,650.24	$45,596.26
Expenditures			
Publishing	$24,774.79		
Reprints	5,349.34	$30,124.13	
Circulation		2,814.76	
Editing and expenses		1,343.35	
Office assistant		1,800.00	
Postage		1,299.42	
Office supplies		629.77	
Honoraria		1,421.00	
Miscellaneous		17.50	$39,449.93
Excess of income over expenditure			$ 6,146.33

Instructions to Contributors

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. As the journal has a flexible publication policy, items not covered in the traditional sections (Articles, Notes, Letters, News and Comment, and Book Reviews) can be given a special place provided they are judged suitable. Readers are encouraged to support regional, provincial, and local natural history publications as well by submitting to them their reports of more restricted significance.

Manuscripts

Please submit, in either English or French, three complete manuscripts written in the journal style. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants, or minerals.

Type the manuscript on standard-size paper, if possible use paper with numbered lines, double-space throughout, leave generous margins to allow for copy marking, and number each page. For Articles and Notes provide a bibliographic strip, an abstract, and a list of key words. Articles also require a running head. Generally words should not be abbreviated but use SI symbols for units of measure. Underline only words meant to appear in italics. The names of authors of scientific names should be omitted except in taxonomic manuscripts or other papers involving nomenclatural problems. Authors are encouraged to use "proper" common names (with initial letters capitalized) as long as each species is identified by its scientific name once.

Although we prefer the names of journals in the Literature Cited to be written out in full, these may be abbreviated following the **Bibliographic Guide For Editors & Authors**, The American Chemical Society, Washington, D.C. (1974). Unpublished reports should not be cited here. Next list the captions for figures (numbered in arabic numerals and typed together on a separate page) and present the tables (each titled, numbered consecutively in arabic numerals, and placed on a separate page). Mark in the margin of the text the places for the figures and tables.

Extensive tabular or other supplementary material not essential to the text, typed neatly and headed by the title of the paper and the author's name and address, should be submitted in duplicate on letter-size paper for the Editor to place in the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository.

The **Council of Biology Editors Style Manual**, 4th edition (1978) available from the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

Illustrations—Photographs should have a glossy finish and show sharp contrasts. Photographic reproduction of line drawings, no larger than a standard page, are preferable to large originals. Prepare line drawings with India ink on good quality paper and letter (don't type) descriptive matter. Write author's name, title of paper, and figure number on the lower left corner or on the back of each illustration.

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Cover: Adult male Spotted Turtle, *Clemmys guttata,* photographed in Point Pelee National Park, Ontario on 26 June 1972 by Donald H. Rivard. Parks Canada photograph from report (contract 72-30) by Donald H. Rivard and Donald A. Smith. See Note on page 411.

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Hunting Success Rates, Foraging Habits, and Prey Selection of Peregrine Falcons Migrating through Central Alberta

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Dekker, Dick. 1980. Hunting success rates, foraging habits, and prey selection of Peregrine Falcons migrating through central Alberta. Canadian Field-Naturalist 94(4): 371–382.

In central Alberta during migration seasons from 1965 to 1979, Peregrine Falcons (*Falco peregrinus*) were seen hunting 958 times. Of 674 interactions with potential prey for which the outcome could be established the prey was seized in 52 cases, a success rate of 7.7%. Success rates for adults and spring immatures were 9.8% and 7.1% in 215 and 363 hunts respectively; fall immatures showed a success rate of 2.4% in 42 hunts. Waterfowl and small shorebirds made up 94% of prey taken. Surprise was the basic element of most hunting techniques. A few prey were captured on the ground or in shallow water; all others were seized in the air and borne down. The great majority of birds seen to be caught failed to use escape tactics routinely displayed by their kind. Lone prey individuals were more often killed compared with individuals in flocks.

Key Words: Peregrine Falcon, *Falco peregrinus*, hunting success rates, hunting techniques, prey selection, Alberta.

Although Peregrine Falcons (*Falco peregrinus*) have been studied extensively in North America (e.g., Hickey 1969; Cade and Fyfe 1970; Fyfe et al. 1976), no quantitative data on hunting efficiency have been published. Eyewitness accounts of the capture of prey by peregrines are few (e.g., Bent 1938; Herbert and Herbert 1965). How waterfowl and shorebirds are caught has seldom been described in detail, although the literature is replete with assumptions and conjecture. Hunting by migrating peregrines in northern Europe was studied by Rudebeck (1950–1951), who recorded a success rate of 7.5%. Fischer (1967) and Treleaven (1961) considered a success rate of 7.5% too low. Brown and Amadon (1968, p. 75) suggested that "probably one attack in four may be successful" and that "much more observation is needed."

This study records (1) the success rate in hunting by Peregrine Falcons of various age groups, (2) their foraging techniques, and (3) the escape tactics of their prey species. The data were collected from 1965 to 1979 in central Alberta while these falcons were migrating.

Study Area and Methods

Observations were made on an area roughly 15 × 2 km situated along the shores of a marshy lake in central Alberta. This area includes grain fields and pastures, with scattered pockets of aspen (*Populus tremuloides*) and willow (*Salix* spp.). Shallow depressions collect melt-water in spring, attracting migrating ducks and shorebirds in large numbers.

Migrating peregrines were seen from 16 April to 30 May and again from 10 September to 4 October (Dekker 1979). The only summer observations were of yearling birds, probably from captive stock reared and released by the Canadian Wildlife Service and the Alberta Fish and Wildlife Division. In the field, adults and immatures can be readily distinguished by dorsal coloration (Godfrey 1966; Dekker 1979).

I located the great majority of peregrines by walking through the area and frequently scanning the landscape through 10-power binoculars. To maximize chances of observing foraging activity, I used the following methods. Resting peregrines were watched until they began to hunt; foraging flights could thereby be observed from their start, but often not to their conclusion. I also watched concentrations of ducks, shorebirds, and passerines for alarm reactions. In such cases, the falcon was usually not observed until its attack was over, but it sometimes attacked next in an adjacent area, allowing me to observe the complete hunt. Some observations were made from a parked car, especially during inclement weather. At other times, I often sat on a stone or against a fence-post in open locations. As long as I remained still, the falcons appeared to ignore me and occasionally pursued their prey in the immediate vicinity. On days when only one or two hunts were seen, observations were written

down at the end of the day. On productive days, most hunts were described immediately after they happened.

Observations were categorized as follows: type A included all hunts for which the outcome was certain because the target was seen either to get away or be captured. Type B included all hunts for which the target was not visible in the concluding stage, but for which the peregrine's success or failure could be deduced from its subsequent behavior: if the falcon turned away and selected a new target, the preceding hunt was classed as unsuccessful; if it landed and was presently seen flying with a prey item or was found feeding, the hunt was termed successful. Type C were hunting flights of which the outcome remained unknown. Type C observations could not be used to compute success rates, but they contributed significantly to understanding of the foraging behavior of peregrines. This category included a high percentage of spectacular long-distance attacks and stoops from great heights, as well as some exceptionally persistent pursuits of a selected target by a single falcon or a pair (see descriptions of hunting techniques).

I used an expanded version of Rudebeck's (1950–1951) definition of a hunt as consisting of one or more attempts by a peregrine to seize a bird of a size that I considered potential prey. For example, swans, geese, and cranes are too large to be suitable prey although peregrines swooped at them on several occasions. Furthermore, some female falcons vigorously attacked Mallards (*Anas platrhynchos*), Common Crows (*Corvus brachyrhynchos*), and Ring-billed Gulls (*Larus delawarensis*), whereas males, especially immatures, sometimes swooped at these species but never seemed intent on making contact, nor were they ever found feeding on such prey. Therefore, swoops and passes by male peregrines aimed at Mallards, crows, and large gulls were not considered to be hunts, nor were swoops by either sex at other peregrines or other large raptors.

A single hunt might include only one swoop or more than 20 aimed at the same bird. A hunt was considered successful if the prey was seized, whether or not the falcon subsequently killed or consumed the prey; four captured birds later were released or escaped. When two peregrines simultaneously pursued the same bird and swooped alternately, I counted the procedure as two hunts, so as to be able to classify the hunts easily if the falcons involved belonged to different age groups. The only successful cooperative hunt seen was also counted as two.

Data were compared statistically by chi-square tests.

Results and Discussion

Success Rates

I observed 958 hunts (420 in category A, 254 in B, and 284 in C). Categories A and B, for which hunting success could be determined, included 52 successful hunts, giving a success rate of 7.7% (Table 1). To my knowledge, only two published accounts of hunting by migrating or wintering peregrines included success rates. Rudebeck (1950–1951) computed a success rate of 7.5% for 253 hunts by migrating peregrines, adults as well as immatures, in Sweden. Clunie (1976) calculated a success rate of 9.6%, based on 62 foraging flights by a single adult female peregrine wintering in Fiji.

Several authors (e.g., Berry 1969) mention that immatures during their first fall are relatively ineffective hunters. During autumn, I saw few peregrines in central Alberta (Dekker 1979), and I noted only 42 hunts by fall immatures. Only one of these resulted in the capture of prey; a Mallard was seized over water but subsequently released. Immatures were relatively common in spring, but their success rate then was 7.1%, not significantly less ($P > 0.05$) than that of adults (Table 1).

Ratcliffe (1962) questioned the intent of some unsuccessful peregrine hunts that he observed and suggested that the falcons he watched were only playing or practising. Most falcons that I saw beginning to hunt after a long rest also did so in a manner that appeared "half-hearted." Their foraging was an extended process, often lasting 1 or 2 h with frequent pauses. The initial part might be termed a "warming-

TABLE 1—Success rates and number of hunts by Peregrine Falcons migrating through central Alberta. For explanation of categories A and B, see Methods

Age group	No. of hunts A	No. of hunts B	No. of hunts A + B	Success rate (%) A	Success rate (%) B	Success rate (%) A + B
Adults	126	89	215	8.7	11.2	9.8
Spring immatures	245	118	363	7.3	6.8	7.1
Fall immatures	25	17	42	4.0	0.0	2.4
Unidentified	24	30	54	4.2	10.0	7.4
Totals	420	254	674	7.4	8.3	7.7

up period" which was followed by a relatively brief period of "serious hunting." During the "warming-up period" immature falcons harassed non-prey species as well as chasing potential prey. Low-level, short-range hunts aimed at groups of resting birds appeared characteristic of this period. Eventually, after several unsuccessful flights, the falcons would gain height and launch long-range attacks with single-minded determination. If my observations had been restricted only to this latter period of "serious hunting," success rates obtained would have been substantially higher than the overall figures recorded. But it is not always possible to distinguish between "half-hearted" and serious attacks; many unsuccessful hunts were frenzied and spectacular, while some successful ones appeared deceptively "half-hearted." I believe that the degree of seriousness of a falcon's attack is related to the state of its appetite. This may not be so on the breeding grounds where adult peregrines forage also for a mate and/or young. Treleaven (1961) recorded 28 hunting flights by breeding peregrines in Cornwall, England, of which 10 succeeded, a success rate of 35.8%. In northern Alberta, I observed breeding peregrines make two single and three cooperative hunts of which two resulted in kills. These data suggest that the success rate among breeding peregrines is significantly greater ($P < 0.001$) than among migrating or wintering adults (Table 2). S. Sherrod and T. J. Cade (Cornell University, Ithaca, New York, unpublished data) reported success rates of 70% and 95% for a captive-raised adult male peregrine which was hunting for a caged brood. It appears that peregrines that forage for a mate and/or young hunt with a greater degree of seriousness than falcons that do not have such motivation. Some adult peregrines are probably more skilled than others or may have acquired specialized hunting methods. Individual peregrines may restrict their attacks to particularly vulnerable prey. Cade (1960) and Herbert and Herbert (1965) reported on the vulnerability of forest birds such as jays crossing rivers near peregrine nests. Breeding peregrines in northern Alberta launched attacks from cliffs or tall trees and often caught juvenile prey species that happened to fly by (Alberta Wildlife Division, unpublished data). Such specialized and opportunistic hunting methods were rare among migrating falcons and seldom seen by Rudebeck (1950–1951) and me.

TABLE 2—Comparison of hunting success rates of adult Peregrine Falcons migrating or on the wintering grounds with the success rate of breeding adults. The differences (chi-square tests) were highly significant ($P < 0.001$)

	No. of hunts	Success rate (%)
Adults during migration in central Alberta	215	9.8
Single adult wintering in Fiji (Clunie 1976)	62	9.6
Breeding adults in England (Treleaven 1961)	28	35.8
Breeding adults in northern Alberta (Dekker, unpublished)	5	40.0

In view of the relatively high rate (35.8%) of hunting success of the breeding peregrines he watched, Treleaven (1961) expressed doubts about the validity of the 7.5% success rate of migrating falcons reported by Rudebeck (1950–1951). Also Fischer (1967) believed that a success rate of 7.5% was too low, although he didn't give a reason. The validity of that figure is supported by the near equivalent success rate (7.7%) found for migrating falcons in this study.

Hunting Techniques and Strategy

All observed hunts took place in the same general locality, and 95% occurred in April and May. Times of day ranged from 5:45 to 22:00 MDT. Weather conditions varied from calm and clear to windy with rain or snow. Extreme high and low temperatures were 36°C and −10°C. Some of these variables affected opportunities for soaring and thereby influenced a falcon's hunting strategy. Peregrines usually soared from mid-morning to late afternoon on sunny and windy days, although cloud cover and even light rain showers did not always prevent them from doing so. Hunting falcons flew at low or medium elevations, and neither sailed nor soared, during periods of heavy cloud, low temperatures, and/or steady precipitation, as well as before mid-morning and in the evening.

Foraging peregrines began their attacks on prey species from distances of up to 2000 m. The vast majority attacked prey that were on the ground or in water. Whether starting from the soaring position or from active flapping flight, the falcons appeared to try to get as close as possible before being noticed; surprise seemed the basic strategy. Once the target was reached, the capture attempt might be a single pass or a series of swoops. I classified the hunts into several groups according to the approach used and listed the number of attempts at seizure in the final stage of each hunt (Table 3).

In the following descriptions of hunting techniques, the term "stoop" is reserved for a descent at great speed with wings flexed and motionless. The term "swoop" is preferred for the sudden increase in velocity and shift in direction, either up or down, with beating wings, that falcons routinely perform when closing with and attempting to seize a flying prey. If a falcon fails to capture the quarry in a downward swoop, it mounts steeply, using the impetus of the

TABLE 3—Hunting methods, success rates, number of hunts, and number of swoops at various prey species. (Number of successful hunts are in parentheses).

Description of hunting techniques	Number of swoops	Number of hunts in pursuit of: Waterfowl	Shorebirds	Waterfowl or shorebirds	Gulls	Small passerines	Other prey species	Not known	Totals	Success rate (%)
Stoop from soaring position aimed at ground-level target	1	3	41(4)	25		10(1)		7	86(5)	
	2–3		14(4)	1	1				16(4)	
	4 or more		2	1					3	
	Unknown		4(4)	2				1	7(4)	
Subtotals		3	61(12)	29	1	10(1)		8	112(13)	11.6
Stoop from soaring position aimed at flying target	1	15(2)			2	1	1		19(2)	
	2–3	1			2	3		4	10	
	4 or more	1(1)					3	1	5(1)	
	Unknown									
Subtotals		17(3)			4	4	4	5	34(3)	8.8
Long-distance flapping flight and descent to ground-level target	1	18(1)	54(6)	13		3		7	95(7)	
	2–3		13	4		1			18	
	4 or more		2					1	3	
	Unknown		6(3)	2					8(3)	
Subtotals		18(1)	75(9)	19		4		8	124(10)	8.1
Low surprise attack aimed at ground-level target	1	34(2)	109(6)	11	3	10		6	173(8)	
	2–3	1	16	1	1	1			20	
	4 or more		1						1	
	Unknown		2(1)					1	3(1)	
Subtotals		35(2)	128(7)	12	4	11		7	197(9)	4.6
Short-range attack on flying target	1	48(4)	53(3)	1	10(1)	12(1)		4	128(9)	
	2–3	3(1)	10		1	3	3	1	21(1)	
	4 or more					1			1	
	Unknown	1							1	
Subtotals		52(5)	63(3)	1	11(1)	16(1)	3	5	151(10)	6.6
Take-off from a perch to pursue a flying target	1	4(2)							4(2)	
	2–3	1	2						3	
	4 or more									
	Unknown									
Subtotals		5(2)	2						7(2)	28.6
Unknown approach	1		1						1	
	2–3		5		1				6	
	4 or more		3			1			4	
	Unknown		2(2)						2(2)	
Subtotals			11(2)		1	1			13(2)	15.4
Slow deliberate search for crouching target	1		6						6	
Tenacious pursuit	10 or more		1				3		4	
Pursuit and swoops by 2 peregrines	4 or more		8(2)			8	2		18(2)	11.1
Other methods	1 or more	1	6(1)			1			8(1)	12.5
Totals		131(13)	361(36)	61	21(1)	55(2)	12	33	674(52)	7.7

descent to gain altitude, and may end the hunt or repeat the swoop, flying up and down in vertical zigzags. The stoop with wings pulled in was seldom used when closely chasing prey.

a) Stoop from soaring position aimed at ground-level target. Peregrines initiated 22% of hunts in categories A and B (Table 3) and 25% in category C from a soaring position at heights I estimated to exceed 1500 m in some instances. When overhead, some soaring peregrines were just visible in 10-power binoculars. Falcons launched their stoops at angles varying from nearly perpendicular to about 30 degrees. Such stoops could be straight all the way or partly curved, convexly or concavely, and were sometimes accompanied by bursts of quivering wing beats. Some stooping falcons were seen to spread their wings just above the ground when attempting to seize a prey. The majority levelled out short of the target and traversed a few to several hundred metres just above the land or water surface with wings motionless and completely or slightly flexed. If the alerted prey rose just ahead, the falcon tried to seize it with its feet, climbing steeply if it failed to make contact. In some cases, additional swoops were subsequently made at the fleeing target or at other birds that flushed below the falcon. Usually the falcon at once flew upwind to resume a soaring position, gaining altitude in preparation for the next attack.

b) Stoop from soaring position aimed at flying target. In 34 cases soaring peregrines stooped at birds that flew by at levels ranging from slightly below the falcon to far below and just above ground or water. As in the previous group, the stoop could be perpendicular or shallow, straight or curving, and terminate in one pass or a series of swoops. In some of the more persistent attacks, the swoops became shallower and changed into level chases or close erratic pursuits.

c) Long-distance flapping flight and descent to ground-level target. This technique accounted for 18% of hunts in categories A and B and 38% in category C. The falcons seldom exceeded an altitude of 150 m and usually flew at approximately half that height. They sometimes flew in a casual manner, until suddenly their wing beats quickened dramatically as prey was sighted and the attack begun. Well before reaching the target, the falcon descended gradually or steeply, thereby increasing its speed. In rare cases, the falcon stooped down, resuming flapping flight just above the ground or water. This second stage of the attack often traversed 500 to 1000 m. Vegetation or sloping terrain sometimes hid the falcon's low approach.

d) Low surprise attack aimed at ground-level target. Some of the hunts included in this group probably began as long-range flapping flights, described above, of which the initial higher stage was not seen. Many falcons, especially immatures, however, began their foraging by flying at great speed at about 1 m altitude over land or water, flushing groups of prey immediately ahead. This hunting technique had a relatively low success rate (Table 3).

e) Short-range attack on flying target. When a long-range attack had failed, or while flapping or soaring at medium or low altitude, peregrines often launched opportunistic attacks on quarry that happened to fly by or were flushed. These falcons changed direction suddenly or flew down steeply, pursuing the prey in a burst of speed, or meeting it head-on, swooping either up or down.

f) Take-off from a perch to pursue a flying target. This opportunistic method is commonly used by breeding peregrines that launch their hunting flights from high vantage points (see Cade 1960; Herbert and Herbert 1965). I saw it used only 7 times. Twice a peregrine flew from a post as particularly vulnerable prey passed: an American Coot (*Fulica americana*) in one instance, an unidentified small grebe in the other. The straight flight of these species probably makes them easy targets. Both the coot and the grebe were captured, although the latter was released and escaped into cover.

g) Slow deliberate search for crouching target. After an aborted long-range approach aimed at flocks of feeding or resting shorebirds, some falcons executed what appeared to be a deliberate search for crouching sandpipers. These peregrines flew slowly, head bent down, about 10 m high. Suddenly, they would dash obliquely downward. The crouching sandpipers rose in the last instant, usually dodging successfully.

h) Tenacious pursuit and more than 10 swoops. About 10% of hunts by fall immatures were exceptionally long chases with repeated swoops. Spring immatures and adults used this method in less than 1% of hunts. Five of 11 such hunts seen became lost to view before their outcome could be ascertained.

i) Pursuit and alternating swoops by two peregrines. Pairs of peregrines were seen to hunt together on 14 occasions. Most pairs were of the same sex and either adult or immature. While one falcon pulled out of an unsuccessful swoop, the other descended to attack. In each of five prolonged pursuits both falcons swooped more than 20 times and became lost to view.

j) Other methods. Several peregrines displayed unusual strategies. One immature male swooped in a cartwheeling dive with wings fully extended at swimming phalaropes. Another immature hovered and descended onto the ground with feet extended in a slow

deliberate manner; small sandpipers rose around it. An adult female twice left its resting place on a stone to fly to the nearby lakeshore, hovered briefly and returned. I believe that it was trying to locate sandpipers it had seen descend in the grass. At the falcon's approach some sandpipers flew away. A recognizable immature female falcon, seen hunting at sundown on three consecutive evenings, habitually flew fast and very low over meadows, shooting upwards spectacularly for 10–15 m when prey was surprised at close range. Plummeting down just as steeply, it tried to seize Red-winged Blackbirds (*Agelaius phoeniceus*) in reedy vegetation. On days when conditions were not favorable for soaring, several peregrines gained height by flying in tight circles or in a peculiar zigzagging fashion, prior to launching their attack on shorebirds or ducks in a slough or pond some distance away.

Prey Selection

In 641 hunts the prey under attack could be identified; 20% were waterfowl, 56% small shorebirds, 3% gulls, 9% small passerines, and 2% miscellaneous prey species (Table 3). An additional 10% of the targets were either waterfowl or shorebirds, so together these two groups made up 86% of the prey hunted.

Some peregrines attacked successively species belonging to different prey groups. Those falcons chose their prey in an apparently opportunistic manner, whereas other peregrines pursued birds of only one group during up to 15 hunts before a kill was made. Some recognizable individuals hunted the same kind of prey exclusively on 3 or 4 consecutive days. They appeared to have specialized on waterfowl or sandpipers or gulls, and some employed particular techniques, but others used several approaches alternately.

a) Waterfowl

All adult peregrines seen during early spring and most adult and immature females observed later preyed almost exclusively on ducks up to the size of Pintails (*Anas acuta*). Mallards were rarely taken and only by females. The hunting methods employed varied greatly (Table 3): of 131 hunts involving waterfowl, 40% were long-distance flapping flights or low-level attacks on resting or feeding flocks of prey on the shores of lakes or ponds. Alarmed ducks rose and splashed down into the nearest water. If approached directly by a low-flying falcon, swimming ducks dove; from very shallow water, they rose and splashed down again instantly when the falcon tried to grab them. The escape tactic employed by flying ducks was to drop like a stone at the last moment, either into water or into vegetation. Some flying ducks dodged and veered aside, especially if attacked from below. High-flying drake Pintails mounted steeply, evading the stoop of a falcon. If further pressed, they dove at speeds barely exceeded by the pursuing peregrine. Several immature peregrines attacked ducks at sundown and at nightfall (Dekker 1979). The following specific hunts are examples of the typical patterns used in hunting waterfowl.

On 4 May 1975 at 11:00, an adult male took off from a fence post to intercept a coot that flew low between two bodies of water. The coot did not dodge. It was seized directly and borne down.

On 10 May 1976 at 11:00, an immature female flew low and fast over grassland to a lake. A drake Pintail flushed just ahead, was seized directly, and borne down to the muddy shore where it was killed in a brief struggle.

On 15 May 1976 at 18:00, a high-soaring peregrine travelled about 1 km in a shallow stoop, assisted by bursts of vibrating wingbeats. It met a string of 10–12 small ducks, and attacked the outermost bird which dropped perpendicularly. The falcon stooped after it about 100 m, overtaking the duck which veered aside and was seized after a violent twisting pursuit. The prey was carried to earth in a long descending glide.

On 22 May 1976 at 19:15, an immature of unknown sex flew about 200 m high in a slow, almost hovering manner before descending steeply to flush half a dozen Pintails from a field. One duck was seized about 3 m above ground and borne down. It had failed to dodge or drop.

On 18 May 1977 at 20:00, two immature females flew over fields, one about 50 m behind the other, then turned and met a pair of Northern Shovelers (*Anas clypeata*) about 200 m above ground. The first falcon seized the duck directly, but released it when the second falcon swooped at it. The first falcon recaptured the duck in a chase of about 10 m and bore it steeply to earth. Both falcons fed on it. The duck had failed to dodge or drop.

On 30 April 1978 at 13:00, an adult female flying over a lake at about 30 m stooped at a pair of Lesser Scaup (*Aythya affinis*) that passed below it in the opposite direction. The ducks splashed down. While the falcon swooped at one diving duck, the other got up and flew on, and the falcon then pursued it. Just before it was overtaken, the duck dropped into water of 20 cm depth. The falcon settled onto the prey with wings spread, and presently dragged it onto a nearby ice floe.

On 7 May 1978 at 11:00, an adult female soared low over a lake and flew down obliquely in pursuit of a pair of Green-winged Teal (*Anas crecca*) that passed over reedbeds. The drake failed to dodge, was seized directly from behind and carried to shore.

On eight occasions during May 1980, after the collection of data for this paper had been terminated, I

observed an adult female take off from a fence post and meet single ducks or pairs and small groups flying over open pasture. It approached just over the ground and swooped steeply up 15–30 m as it tried to seize a duck from below, either from the front, the side, or behind. Most ducks appeared to see the falcon and turned away. Two failed to dodge the upward swoop: a drake Lesser Scaup was seized from behind, a female Pintail from the side. None of the eight ducks plunged down to take cover on the ground, probably because the attack took place over grassland that offered insufficient cover, and/or because the falcon was flying much lower than they were.

b) Shorebirds

Migrating shorebirds varying in size from Black-bellied Plover (*Pluvialis squatarola*) to Buff-breasted Sandpiper (*Tryngites subruficollis*) were hunted by peregrines of both age groups and sexes. Smaller species, down to Semipalmated Sandpipers (*Calidris pusilla*), were caught only by males. In about 95% of observed hunts, peregrines attacked feeding or resting flocks, using a variety of techniques. The element of surprise was common to 26 out of 36 kills observed. Although some individual sandpipers froze and crouched when alarmed, flocks usually rose, uttering sharp calls, and drew together in compact formations that left the area for new feeding locations, or coursed back and forth for some time, attaining considerable height in some cases. Such densely packed flocks were very seldom attacked. The alternating light and dark flash pattern of wheeling sandpipers appeared to function as a long-distance signal to alert neighboring flocks, that rose in obvious response. If peregrines had hunted a certain bay or slough several times during a few hours, the shorebirds showed agitated flocking behavior.

Shorebirds that flushed just ahead of a rapidly approaching peregrine often avoided capture by dropping onto the ground or into water, taking off again instantly in the opposite direction. Most peregrines that missed in this way flew on and attacked elsewhere. But some swooped upwards nearly vertically over such prey, stooping down again to grab it on the ground or to pursue it. Sandpipers that had splashed down into water sometimes could not rise at once and dove or lurched about, trying to dodge repeated swoops by a peregrine. In one such hunt observed at very close range, the sandpiper managed to find safety in a tussock of rushes. In a successful hunt seen by R. Slagter (personal communication), the repeatedly diving sandpiper was eventually seized by one wing and carried aloft. Shorebirds that flushed early enough to reach top speed before being overtaken by an attacking peregrine less commonly dropped down, but often dodged instead, veering sharply and gaining altitude swiftly. In prolonged chases, some sandpipers descended and took cover in vegetation. The peregrine might then fly around the spot in tight circles and swoop up to a dozen times in efforts to flush the hiding prey. Other shorebirds successfully dodged up to 20 swoops until the falcon gave up. A Short-billed Dowitcher (*Limnodromus griseus*) outclimbed a pair of cooperating immature female peregrines in a chase that started at ground level and reached an altitude of about 150 m. The outcome of five prolonged chases of shorebirds by single falcons or pairs could not be ascertained as the birds became lost to view. When they had the advantage of superior height, peregrines could quickly overtake fleeing shorebirds but showed little manoeuverability. Between swoops, pursuer and pursued were often over 50 m apart.

Of 36 shorebirds caught, 27 were sandpipers. None of these 27 hunts involved a long pursuit. Every one of the 14 sandpipers caught under conditions that allowed a clear view was seized at the falcon's first try.

The single most preyed-upon species, constituting 53% of 32 identifiable shorebird kills, was the Pectoral Sandpiper (*Calidris melanotos*). It was also the most common migrating shorebird; its numbers in the study area sometimes exceeded 10 000 (unpublished data). I witnessed no peregrine predation on locally breeding adult Killdeers (*Charadrius vociferus*), Willets (*Catoptrophorus semipalmatus*), Marbled Godwits (*Limosa fedoa*), and Avocets (*Recurvirostra americana*), although I found a few plucked remains of Killdeer and Marbled Godwit.

The following specific hunts are examples of the typical patterns used in hunting shorebirds.

On 8 May 1972 at 16:30, an adult female soared very high and stooped to ground level, swooping up steeply. When a single Pectoral Sandpiper flushed below it, the falcon stooped and caught it just above a slough. The sandpiper had failed to dodge or drop back.

On 16 May 1974 at 16:30, an immature female flying at moderate altitude descended gradually and raced low to a lakeshore, flushing a lone Black-bellied Plover about 15 m ahead, and seizing it directly from behind, 3 m above ground. The plover had not dodged, although there appeared to have been ample time and warning.

On 13 May 1975 at 14:00, an adult male raced low over a marsh, where dowitchers were flushing and disappeared for a moment behind reeds. It reappeared, hovering 2 m above water for several seconds, plunged in feet first, up to its belly, and came up with a dowitcher, which it carried to a nearby meadow. It is probable that the dowitcher had dropped into the water and dived when pursued.

On 20 May 1975 at 17:45, an adult female peregrine soared before stooping at a shallow angle, traversing about 1500 m. The last 200 m were covered horizontally, low over a bay. Half a dozen Black-bellied Plover flushed from the opposite shore in the last instant. One was seized directly, about 1 m above the mud.

On 13 May 1977 at 16:15, an immature female flew at about 30 m over grassland among numerous flushing shorebirds. Suddenly it descended at an angle of about 45° to overtake and directly seize a Pectoral Sandpiper that flew low over the ground and failed to dodge or drop.

On 23 May 1977 at 21:45, just after sundown, an immature female took off from a fence post and flew about 1000 m, climbing gradually to about 150 m where it reached a dense flock of about 100 Buff-breasted Sandpipers that had risen in alarm well ahead of the falcon's approach. The peregrine seized a sandpiper directly and sailed down with it. The sandpiper had failed to dodge or drop. On the moment of capture, the flock scattered.

On 9 May 1978 at 11:30, an immature male and an adult female sat on adjacent fence posts. The male flew off to the shore of a lake and pursued a Lesser Yellowlegs (*Tringa flavipes*) that flushed. The female joined the chase and each peregrine made three or four swoops before the male seized the prey, only to release it again when the female swooped at it. The shorebird flew on for a short distance, pursued by both peregrines, and was captured by the female at its next swoop.

On 15 May 1978 at 13:00, an immature female soared and then stooped to ground level, where it raced over open pasture land, flushing flocks of Pectoral Sandpipers. About 6 m before being overtaken, one sandpiper dropped into grass. The peregrine swooped up over it and descended to seize it on the ground. This Pectoral had not dodged in the proper way, as it dropped too early and failed to get up in time.

During May 1980, I saw an additional 17 shorebird hunts of which 13 involved flocks of Pectoral Sandpipers feeding on level grassland. Five of these were successful. The falcons used a variety of hunting methods, but in all cases the final approach was very low over the ground, either a gliding or flapping flight. In one successful hunt, a flushed sandpiper was seized directly. In each of the other four, a sandpiper dropped into the grass just before being overtaken by the falcon, which swooped steeply up 3–30 m, and descended quickly to seize it on the ground. The grass was longer than usual (10–50 cm) for this time of year, which probably helped the peregrine to conceal its approach. Also, the long grass may have given the plunging sandpipers a false idea of cover, which may explain why they failed to get up immediately after the falcon had overshot its mark.

c) Gulls

Gulls were common in the study area, but they were not often hunted. They dodged nimbly when attacked from above, evading a peregrine's stoop by mounting steeply. One Ring-billed Gull barely escaped capture when the attacking peregrine followed it very closely and attempted to strike it from below. One immature female peregrine consistently hunted flying Franklin's Gulls (*Larus pipixcan*) by making a single upward swoop, meeting them head-on or from the side. On only two occasions were high-soaring peregrines seen to stoop to ground level to flush resting gulls, which they attempted to seize as they rose just ahead. R. Slagter (personal communication) witnessed the last stage of such a hunt with an adult falcon seizing a Franklin's Gull just as it flushed from a slough. Rose (1965) followed a hunt by car and saw the capture of an immature Franklin's Gull that was chased for more than 6 km by an immature peregrine in fall. I saw two persistent pursuits of gulls by fall immatures but was unable to ascertain their outcome.

The only successful gull hunt watched was that on May 20 1978 at 11:30, when an immature female that had already made several low rushes at flocks of resting gulls, left its resting place on a stone and climbed against the wind over a lake. At about 100 m altitude, numerous Franklin's Gulls hung and hovered, hawking for flying insects. The peregrine seized one directly from below and behind, turned and flew back to land, carrying the limp prey.

d) Small passerines

Although blackbirds were attacked by peregrines of both sexes, larks, sparrows, longspurs, and buntings were hunted only by males. The success rate for 55 hunts was only 3.6%, lowest of four different groups of prey species (Table 4). Once airborne, the small

TABLE 4—Number of hunts and success rates of peregrines attacking various groups of prey species (61 hunts that were directed at either waterfowl or shorebirds were divided proportionally between these two groups. See Table 3)

	Number of hunts	Number of kills	Success rate (%)
Waterfowl	153	13	8.5
Shorebirds	400	36	9.0
Gulls	21	1	4.8
Small passerines	55	2	3.6
Other prey species	12	0	—
Species unknown	33	0	—
Totals	674	52	7.7

birds dodged very effectively. On several days during the cold spring of 1979, when flocking shorebirds were scarce or absent, a pair of adult male peregrines hunted consistently for Snow Buntings (*Plectrophenax nivalis*). They attacked feeding flocks in deep stoops from a soaring position, swooping alternately at single birds, but missing every time. Twice one of the partners had consumed a small passerine immediately prior to joining or initiating the chase. The buntings became extremely agitated after repeated attacks over a period of about an hour. Their feeding routine was disrupted by continuous alarms, real or false; the first birds to land would rise again, taking the flock with them, before the last in the group had a chance to touch down. In response to the appearance of a hunting peregrine some small passerines crouched; after flocks of buntings had risen, individual birds were seen to flush later. On two occasions, falcons swooped at dense flying flocks, splitting them and pursuing single birds.

Blackbirds, both Red-winged and Yellow-headed (*Xanthocephalus xanthocephalus*), were attacked in 15 hunts by peregrines that scattered feeding flocks or swooped at single birds. No successful hunts were seen. An adult male peregrine made a spectacular, vertical stoop from a very high soaring position at an American Robin (*Turdus migratorius*) flying low over ploughland. After dodging two additional swoops, the robin reached the safety of woods.

I saw two successful hunts directed at small passerines.

On 15 May 1976 at 17:00, an immature male flew over pasture at about 8 m meeting several small birds head-on, and seemingly collided with one that dropped into the grass. The peregrine turned and landed on its prey, which proved to be a Savannah Sparrow (*Passerculus sandwichensis*). Although it seemed to have been hit in mid-air, I believe that it dodged, then failed to get up in time.

On 5 May 1979 at 12:00, a soaring adult male descended obliquely, flapping at first and then in a shallow stoop, spreading its wings just over the ground as a large flock of Snow Buntings rose. One was seized directly, a split second after it flushed.

e) Miscellaneous prey species

Although peregrines were seen to mob or swoop at crows on about 20 occasions, only four interactions qualified as hunts (see Methods). An adult female falcon stooped from a soaring position to attack a crow flying over a lake at an altitude of about 300 m. After 10–12 swoops of gradually decreasing depth, the falcon eventually followed the prey closely, attempting to seize it from below or the side. The crow was left alone near a woodlot. Three other single crows were attacked by large immature falcons; two escaped into trees after dodging 8–10 deep swoops in a chase of about 2 km; the third evaded three close swoops despite the handicap of ragged wings. In open country, flocks of crows were observed to climb high at the approach of a falcon, or take cover in trees, on fence lines, or barns.

Peregrines often swooped or stooped at other raptors but only four attacks were directed at species small enough to be considered potential prey. One immature female falcon, soaring very high, made a single stoop at a Sharp-shinned Hawk (*Accipiter striatus*) that soared below it. On two occasions, soaring immature females attacked unidentified small raptors high in the sky, driving them down in very violent pursuit, swooping 8–12 times, but desisting close to the ground. A fourth immature female hunted a Merlin (*Falco columbarius*) in level flight low over grassland, making three shallow passes, each time dropping 2–5 m behind, and gaining again very slowly. Eventually, the Merlin climbed at an angle of about 30°, reaching an altitude of 200–300 m where it was nearly overtaken by the closely following peregrine. The Merlin suddenly stooped down vertically with the larger falcon in close pursuit, and disappeared from view behind a rise in the land. Seconds later, only the Merlin reappeared and vanished into the distance. The hunt covered approximately 2 km from first sighting to the Merlin's final escape.

Short-eared Owls (*Asio flammeus*) were targets of three unsuccessful hunts by immature female peregrines. Two swoops were made in each of two cases. In the third case, a pair of falcons alternately attacked an owl, which climbed steadily while dodging a total of 18–22 swoops.

The following incidents were not included in the tabulations for this paper. Two immature female falcons were walking on grass that was nearly covered with swarming midges (chironomids). For several minutes they appeared to be picking up insects with their bills. During early fall, an immature male tried twice unsuccessfully to catch flying dragonflies. A summering immature male, probably released from captive stock, caught two or three dragonflies and ate them on the wing. An adult female and a recently released captive-raised immature female flew down from posts and seized voles or mice. On two occasions, immature falcons fed on the carcasses of ducks apparently killed by botulism.

Killing Practices, Food Utilization, and Piracy

Several authors (e.g., Godfrey 1966; Beebe 1974) have claimed that peregrines often strike large prey a blow in the air, sending them tumbling to earth, dead or badly injured. In all successful hunts that I witnessed in Alberta, where the prey was captured in the air and where I could clearly see the moment of con-

tact, the prey was seized and carried to earth. I saw no evidence that birds were knocked out of the air, although the plunging escape tactics routinely used by waterfowl and shorebirds might look as if a hit had occurred. Of 18 kills observed by Rudebeck (1950–1951) only two involved prey that was hit and fell to earth lifeless. While observing wintering peregrines in the Netherlands, I saw an adult falcon strike a racing pigeon (*Columba livia*), resulting in a burst of feathers. The pigeon managed to reach the cover of woods where I found it dead minutes later. No doubt some peregrines kill or maim their prey by striking with the claws, but such techniques may be far less common than is generally believed. The observer of hunting peregrines should conclude that a blow is struck only if feathers are seen to fly or if the prey is found or seen to be wounded or dead.

Most prey that I saw seized by a peregrine appeared to be stunned instantly, although two sandpipers flapped one or both wings while being carried to the ground. Three Pectoral Sandpipers escaped after the falcon had landed. Two were recaptured after chases of 4–6 m; the third managed to reach cover 25 m away where it stayed despite the falcon's repeated swoops. Two ducks and one Lesser Yellowlegs that were seized, held for a moment, and released in the air, flew away as if unharmed, but were recaptured in seconds. Of two other ducks that were seized and released, one flew away and dropped into water at the next attack of the falcon. The other fell into reeds as if dead. A small unidentified grebe lost a puff of feathers when it was seized from behind and released. It flew on and dropped into cover just before the next attack. Two falcons seen to catch sandpipers in the air and transport them for some distance, brought their prey forward in their feet and bent down as if to bite, probably to kill the prey. Waterfowl were killed on the ground after a brief wing-flapping struggle. The neck appeared to be broken in most victims examined after the falcon had finished feeding.

An adult male captured and killed a Coot but didn't eat it and flew away after a few minutes. On 8 May 1980, I observed an adult female seize a drake Lesser Scaup, kill it on the ground, then leave it and fly to a nearby fence post; presently it took off and attacked other ducks. Possibly these falcons would have returned later to their kills had they been available, but I collected both the Coot and the scaup for toxic chemical analysis. I believe that the falcons were still in the "warming-up period" at the time of these kills and were not hungry enough to start eating.

Birds up to the size of Pectoral Sandpipers were always eaten completely except for feathers, some entrails, one or two legs and the head, or part of it. Of ducks, gulls, and the larger plovers usually only neck and breast meat were consumed. Several falcons returned to their kills 2 or 3 h later.

Brown and Amadon (1968) examined the food requirements of raptors and gave 104 g as the average daily intake of captive peregrines during winter. They suggested that one substantial kill may last large falcons in the wild for several days. The migrating falcons observed in this study appeared to kill several birds daily. Duck-hunting falcons were seen to eat in early morning, in late morning and again in late afternoon or evening, apparently capturing two prey daily. When my presence near an early morning kill made it unavailable for a female falcon's second meal, it caught another duck before leaving the area. Most probably it hunted again at the end of the day. Shorebird hunters foraged at least 3, often 4, and perhaps 5 or 6 times daily. An immature female falcon that had eaten an entire Stilt Sandpiper (*Micropalama himantopus*) in one instance and most of a Black-bellied Plover in another, began foraging again after a rest of 2 h. Three falcons each ate a sandpiper or small passerine and chased prey species immediately afterwards.

The waste in predation on large prey by migrating peregrines can be high; one immature falcon that killed a drake Pintail ate only part of the neck and breast, and moved out of the area after a rest of about 15 min. Such partial use of food was typical only of falcons that killed large prey just before leaving on migration. The remains of peregrine kills were commonly eaten by crows, Black-billed Magpies (*Pica pica*), Buteo hawks, and Marsh Hawks (*Circus cyaneus*). Some peregrines resting near recent kills chased scavengers away from the remains; others seemed indifferent. Scavengers frequently waited near a feeding peregrine, moving in soon after it flew away. A female falcon eating from a recently killed duck was surrounded by six Marsh Hawks. A Rough-legged Hawk (*Buteo lagopus*) stooped at this falcon and took over the prey, but left after the falcon made a series of violent swoops at it. Another Rough-legged Hawk hovered low over a feeding female peregrine, which spread its wings over the prey until the hawk flew on.

Red-tailed (*Buteo jamaicensis*) and Swainson's Hawks (*Buteo swainsoni*), as well as Marsh Hawks and crows, were seen to flush male peregrines, which were forced to transport their prey long distances before feeding. Pursued by three Buteos, one adult male peregrine soared upwards to a great height, where it ate its prey on the wing. Male peregrines also ate while sailing or soaring following piracy attempts by female peregrines (Dekker 1979). Intraspecific attempts at food theft were often observed. Chases were usually short, although one immature female vainly chased an adult female for about 2 km, climbing steadily. An adult male dropped its freshly caught

sandpiper when pursued and overtaken by an immature male. The prey fell into reeds and was not retrieved. Twice an immature male was robbed by an adult female. Peregrines were observed to steal food also from other raptor species. An adult male peregrine chased and robbed a Sharp-shinned Hawk. On two occasions an unidentified peregrine overtook a food-carrying Merlin that dropped a freshly caught sandpiper. In both cases the peregrine swooped down after the falling prey and disappeared from view behind reeds. An adult male Marsh Hawk was forced to drop a small prey by a stooping adult male peregrine, that dived after the morsel, but failed to retrieve it before it fell into trees. Two other male Marsh Hawks retained their small prey despite repeated violent swoops by immature female peregrines.

Selective Effect

Rudebeck (1950–1951) and Eutermoser (1961) have presented evidence of a selective effect of peregrine predation as shown by a relatively high percentage of crippled or otherwise abnormal individuals among prey that they saw taken by peregrines. They claimed that the peregrine selectively attacks birds with deficiencies of some kind. I could not detect any abnormalities in the outward appearance of prey seen to be seized by peregrines except for one duck that was probably crippled by botulism; however, a high proportion of birds seized failed to use escape tactics routinely used by their kind. Of 420 birds attacked under category A conditions that allowed me to see exactly what happened, 394 birds did use such escape tactics. Only six (1.5%) of these were captured. All of 26 birds that failed to make a completed dodging attempt were seized. The difference is highly significant ($P < 0.001$). Almost all birds that didn't dodge were caught directly at the falcon's first try. These birds flew on a straight course or flushed just ahead of the peregrine and failed to veer aside or drop into water or onto the ground. A few birds that dropped well ahead of the falcon failed to get up before the falcon turned and swooped down. For specific examples, see descriptions of successful hunts. The reasons why these prey dodged in an incomplete way or not at all are open to speculation. It is possible that some of the birds seized directly from behind didn't see the peregrine, as was almost certainly the case with the gull seen to be killed. Other birds, such as one of the plovers and the Snow Bunting, were surprised at such close distances that there seemed no chance to dodge. The majority of captured ducks and shorebirds, however, appeared to have had fair warning of the peregrine's approach and enough time to dodge, yet they failed to do so or were too late to try. The conclusion appears justified that most of these birds showed abnormal escape behavior. I emphasize that no prey species appeared capable of flying faster than a peregrine, and that attacked birds could avoid capture only by taking cover or dodging. Prey that dodged was rarely caught. As reported by Herbert and Herbert (1965), breeding peregrines that specialized on hunting migrating forest birds over water routinely captured them despite attempts at dodging. Probably those forest birds would have been caught much less often over land, where tree cover was available.

A prey that flushes well ahead of an approaching peregrine will probably have a better chance to dodge effectively than one that is surprised at close range. Therefore, early warning is important. Powell (1974) proved experimentally that feeding flocks of Starlings (*Sturnus vulgaris*) responded more quickly than single birds to a flying model hawk, and that individuals in a flock spent less time in surveillance. Assuming that the same applies to other species of flocking birds, lone ducks or shorebirds feeding on the ground should be more vulnerable than feeding flocks to surprise attacks by peregrines. Out of 226 attacks observed under category A conditions and directed at prey species on the ground or in shallow water, 17 involved lone individuals and 209 were aimed at flocks. The respective numbers of kills were 4 (24% of the total) and 13 (6%), suggesting that lone individuals were significantly more vulnerable ($P < 0.02$).

It is improbable that peregrine predation has any selective effect when falcons restrict their attacks to prey individuals that happen to be in a vulnerable position, such as forest birds migrating over water. Selective effect is more likely to occur when peregrines attack mature prey species in their preferred habitat. For that reason, this study appears to be ideal for the examination of selective effect, especially since many falcons were seen to hunt in a "half-hearted" way. I believe that a "half-hearted" peregrine hunts more selectively than one which is "deadly serious." During the "warming-up period," migrating falcons appeared to "test" their prey by a single swoop, giving up at once if the prey dodged effectively. After a number of such "half-hearted" hunts had failed, the falcons attempted to take their prey by surprise, or became more tenacious. Such seriously hunting falcons appeared capable of catching some of their prey before they had a chance to dodge, or despite their dodging.

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Status and Foraging Distribution of White Pelicans, Prince Albert National Park, Saskatchewan

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The White Pelican (*Pelecanus erythrorhynchos*) population breeding at Lavallée Lake, Prince Albert National Park, has increased since 1938. Pelicans fledged increased from 700–1500 between 1938 and 1940 to a high of 2696 in 1976. Nesting islands decreased from three to one but sub-colonies increased from 3 to 15 over that period. Nesting shifted from treeless areas to areas with an overstory of coniferous forest. Most foraging during the breeding season was outside the park at Montreal Lake.

Key Words: Saskatchewan, White Pelicans, *Pelecanus erythrorhynchos*, populations, reproduction, foraging, population dynamics.

Of the 26 active White Pelican (*Pelecanus erythrorhynchos*) breeding locations in Canada (Vermeer 1970), only the one at Lavallée Lake (54° 18′N, 106° 35′W) in Prince Albert National Park (PANP) has effective protection from human encroachment. This breeding area has been designated for protection as one of the three most important and delicate wildlife resources in the park (Anonymous. 1979. Proposal for a management plan, PANP. Unpublished report, Parks Canada, Winnipeg. 17 pp.). Accordingly, access to the vicinity is prohibited except by special permit. The restrictions have been set because of the sensitivity of these birds to disturbance (Houston 1962; Sanderson 1966; Carson 1966) and because no other Canadian national park supports a breeding population of White Pelicans.

Parks Canada recently recognized that strict enforcement of access prohibitions had restricted understanding of the ecology and status of this protected population. A request was made to the Canadian Wildlife Service (CWS) for assistance in developing a non-destructive method of monitoring annual status of the breeding population, and in determining distribution of White Pelicans away from the nesting sites. This paper reports the findings of the CWS study during the summers of 1975 and 1976.

Aside from periodic nest counts reported by Thompson (1932), Soper (1952), Lies and Behle (1966), Vermeer (1970), and Boeker (1972), little is known of the Lavallée Lake colony, one of the largest in Canada. Furthermore, despite various population studies in North America, little information has yet been presented on spring and summer foraging grounds.

Parks Canada places great importance on preservation of the White Pelican breeding area. Yet a large proportion of the population forages beyond the park boundaries where it is subject to human disturbance, particularly by the extensive pulpwood harvesting in the vicinity. Logging roads increasingly provide access to formerly inaccessible lakes, while terrain disturbance and creation of large clear-cut areas affect watershed stability. Regular monitoring of the White Pelican population at Lavallée Lake may prove an important measure of environmental quality in this part of Saskatchewan.

Study Area

Prince Albert National Park and adjacent areas were surveyed to document foraging distribution of White Pelicans (Figure 1). Focal point of the study, however, was Pelican Island centrally located in Lavallée Lake in the extreme northwest corner of the park (Figure 2). Lavallée Lake is located in a broad uniform lowland characterized by bog and little relief. The substrate is predominantly glacial outwash with poor drainage and the vegetation is typically boreal (Rowe 1972).

Pelican Island lies in the central part of the lake 0.8 km from the nearest shoreline. The island is 0.8 km long east–west with an area of about 10 ha. The eastern section is predominantly White Spruce (*Picea glauca*) – Balsam Fir (*Abies balsamea*) forest (age 125 yr), occasionally interrupted by mature individuals of Balsam Poplar (*Populus balsamifera*) and White Birch (*Betula papyrifera*). In contrast, the treeless western portion supports a growth of Stinging Nettle (*Urtica dioica* ssp. *gracilis*), except where White Pelicans and Double-crested Cormorants (*Phalacrocorax auritus*) have nested or where interrupted by restricted areas of Bluegrass (*Poa palustris, P. pratensis*), Rough Cinquefoil (*Potentilla norvegica*), or Strawberry Blite (*Chenopodium capitatum*). Along the shoreline is a community with Bluejoint (*Calama-*

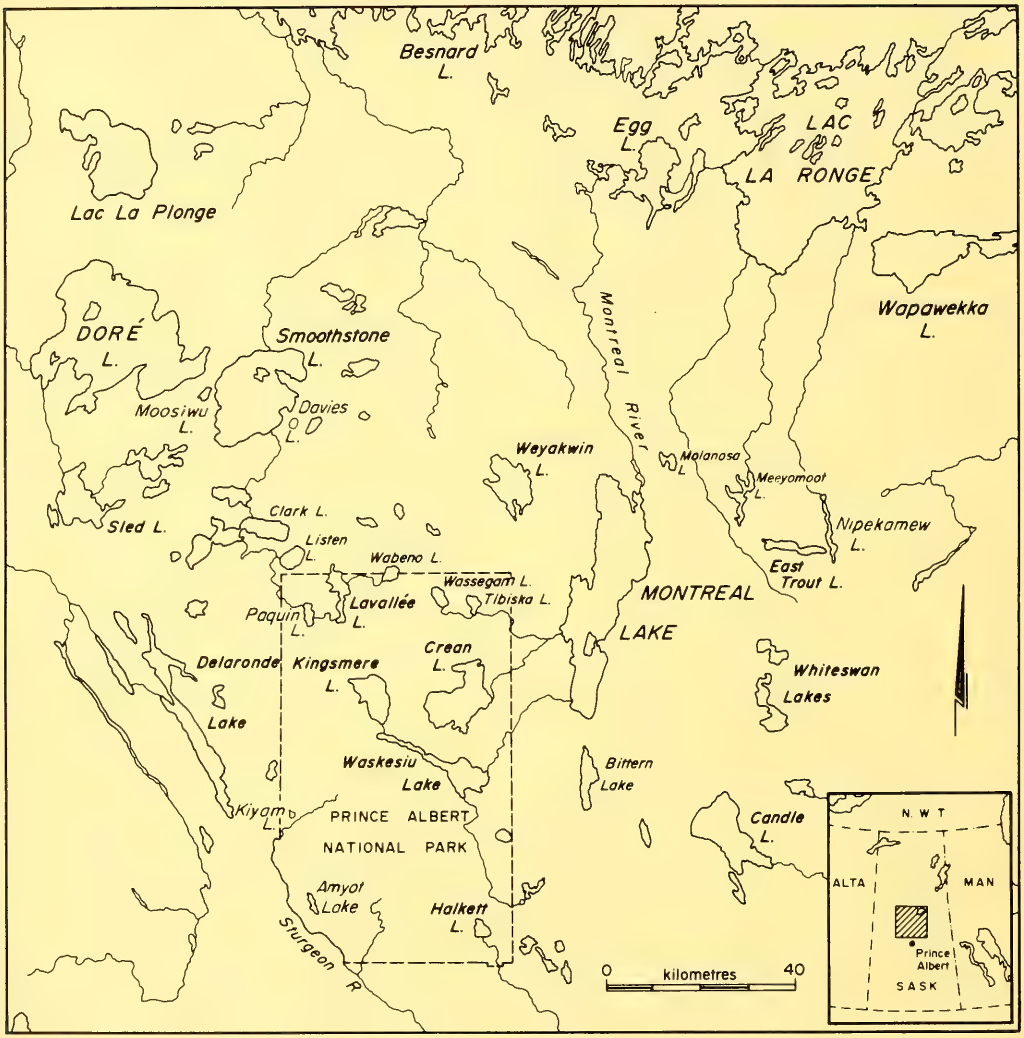

FIGURE 1. The study area, encompassing Prince Albert National Park and vicinity.

grostis canadensis), Narrow-leaved Dock (*Rumex mexicanus*), and occasional willows (*Salix* spp.).

At its highest point Pelican Island rises 4.5–6.0 m above water level. The shores rise abruptly 0.8–1.1 m throughout and are never breached by fluctuating water levels. All southwest-facing shoreline has narrow sandy beaches, but the remainder is rocky and steep. Soils are shallow, underlain by a thin mantle of sand and large boulders.

Pelican Island and two very small adjacent islands known locally as Rocky Island and Gull Island have been consistently used by colonial nesting birds including White Pelicans, Double-crested Cormorants, and Great Blue Herons (*Ardea herodias*). Soper (1952) also reported nesting by Common Terns (*Sterna hirundo*), Black Terns (*Chlidonias niger*), Herring Gulls (*Larus argentatus*), and Ring-billed Gulls (*Larus delawarensis*).

Wapiti (*Cervus elaphus*) use Pelican Island as a calving ground, which confirms the absence of large mammalian predators that might disrupt breeding success of the birds.

Methods

Nest Survey

The breeding population was first estimated by

FIGURE 2. Pelican Island viewed from the southeast.

counting nests on aerial photographs taken during the peak nesting period. Mean arrival date of pelicans at Lavallée Lake is 20–25 April (PANP wildlife observation records). Given some lead time for nest-site selection plus the 29-d incubation period (Bent 1922), maximum numbers of nests would be expected about 1 June (R. Beaver and V. E. Lewin, University of Alberta, Edmonton, unpublished data), although we did not determine when nesting was initiated. On 3 June 1975, 49 vertical photographs were taken of the three islands in Lavallée Lake. A hand-held Hasselblad 400 EL camera (70 exposure film magazine) was used, shooting through a port in the aircraft floor. Exposures were made from elevations of 640, 793, 1129, and 1280 m agl with both 80- and 250-mm lenses. The survey was conducted around 09:30 CST to avoid the peak period of nest relief at midday (Schaller 1964) when some nests would have two adults present and others only one. A count of all White Pelicans visible in nesting colonies from black-and-white enlargements constituted the estimate of nests.

Nest sites were verified by ground reconnaissance in late August or early September to avoid disturbing the colony. Evidence of nesting included vegetation denudation, nest mounds, egg-shells, and dead young.

Fledgling Census

After problems were encountered with counts of adults (see Discussion), fledglings were censused by aerial photographs on 27 July 1975 and 11 August 1976. High-angle oblique photographs were taken from the aircraft using the Hasselblad 400 EL with 105-mm lens and Kodak Aerochrome MS 2448 film. An initial low-level pass served to flush pelicans at each sub-colony from shore into the water where they spread out sufficiently to allow excellent conditions for photography. These flights were conducted before the midday feeding period marked by incoming and outgoing flocks of adults. Estimates of fledglings were made by projecting the color transparencies on a 9-m^2 screen and counting individual young, which were distinguished from adults by their dusky gray color and short gray bills (Bent 1922).

Identification of Foraging Grounds

Three aerial surveys were carried out to determine the distribution of White Pelicans away from the nesting sites. Two observers in the aircraft recorded all sightings of White Pelicans. The surveys were generally restricted to early and mid-morning, when adults were most likely to be foraging. Large lakes such as Montreal Lake (Figure 1) were surveyed by transects, one along each shore and one longitudinally through the central area, while smaller water bodies were covered by flying along shores.

Results and Discussion

Population Status

On 3 June 1975 we estimated a minimum of 1293+ nests in 11 sub-colonies each with from 18 to 390+ nests (Table 1). Eight sub-colonies were on the treeless western half of Pelican Island, and three (Sites 9, 10, 11) were under heavy tree cover on the eastern half (Figure 3). There were no nests on Rocky and Gull islands.

It was impossible to make total nest counts for sub-colonies under tree cover; therefore, a much larger nest population was likely. Because a large proportion of nests occurred in treed areas, aerial censusing during the nesting period was considered an inadequate technique for monitoring population status and trends. Also, image resolution was not totally satisfactory and could have been improved by flying lower and using a larger-format camera. Other limitations of this technique include biases introduced by

TABLE 1—Estimated nests, 1975, and fledged White Pelicans, 1975 and 1976, at Lavallée Lake, Prince Albert National Park

1975			1976	
Site[1]	No. of nests	No. of fledglings	Site[1]	No. of fledglings
1	68	46	1	312
2	18	10	2	327
3	57	18	3	49
4	136	0	4	6
5	50	11	5	184
6	196	177	6	147
7	139	32	7	1290[2]
8	36	36	8	239[2]
9	162	233	9	137
10	41	67	10	5
11	390+	1437		
Total	1293+	2067		2696

[1]Sites not comparable between years.
[2]Approximately 5% of the birds counted at these sites could not be distinguished as fledglings. The totals shown have been reduced from the numbers observed.

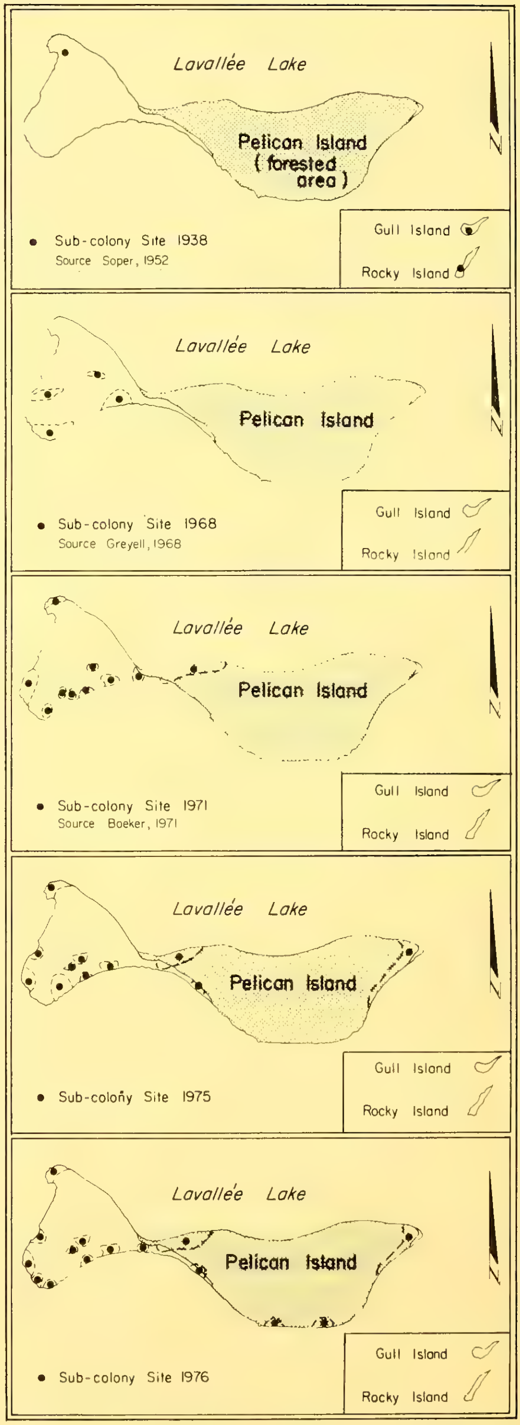

FIGURE 3. White Pelican sub-colonies 1938–1976. Shading indicates continuous forest cover.

loafing adults (R. Beaver and V. E. Lewin, unpublished data) and nest abandonment (Vermeer 1970), which together could generate overestimates of 20 to 40% (Knopf 1975). It is unlikely that presence of juvenile pelicans would introduce a bias since Schaller (1964) observed that immatures did not stay at nest sites on Molly Islands once nesting began.

We do not know if nesting, and similarly the breeding population, has increased since 1938 when monitoring began (Table 2). The reports for 1938 and 1940 (both ground surveys) were of birds, not nests, and may have included loafing adults present during nest relief. The nest counts of 1968 and 1971 were conducted by ground survey and aerial photographs respectively, and may not be comparable, but they do indicate stable populations. Our conservative nest count in 1975 suggests that at least nesting has not declined.

The fledgling census of 27 July 1975 resulted in a count of 2067 (Table 1). Of this total 84% were hatched from nests located under trees. Fledglings counted on 11 August 1976 totalled 2696; hence 629 more young fledged in 1976 than in 1975, and breeding sites expanded from 11 to 15.

Number of young fledged seems to have increased since 1938 (Table 2). The ground counts by Ferrier and Soper, made in late June and early July respectively, were likely subject to estimating bias; they would have missed late hatches, and would not account for all the pre-fledgling mortality. These conditions would temper observed trends.

It is unclear whether the apparent increase in fledged young from 1975 to 1976 related to changes in breeding success, an influx of adults from other breeding grounds, or both. Diem (1979) showed that changes in breeding population at Molly Islands were probably due to the exchange of adults with other colonies. R. Beaver and M. Ballantyne (1977. A preliminary study of the breeding behaviour and distribution of the White Pelican in the Alberta Oil Sands Area. Unpublished report, Alberta Oil Sands Environmental Research Program, Edmonton. 62 pp.) reported that the entire population of White Pelicans which traditionally nested at Namur Lake in Alberta (Vermeer 1969), had occupied a new nesting area to avoid human disturbance. The Doré Lake colony in Saskatchewan approximately 65 km NW of Lavallée Lake, which once supported 600 nests (Vermeer 1970), was abandoned about 1971 (A. J. Erskine, CWS, personal communication). It is not known where and when this population resettled.

TABLE 2—Population status of White Pelicans at Lavallée Lake, Prince Albert National Park

Date	Number of Adults	Nests	Young	Islands	Source
1938	1930	—	733	3	Ferrier (*in* Soper 1952)
1940	1800	—	1500	3	Soper 1952
1968	—	1161	—	1	Greyell, B., unpublished
1971	—	1365	—	1	Boeker 1972
1975	—	1293+	2067	1	This study
1976	—	—	2696	1	This study

In 1976 not all fledgling groups were on or around nest sites at Pelican Island as in 1975. Some fledglings were loafing on the lake or had moved to Rocky and Gull islands and to a point on the southwestern lakeshore. No evidence of pelican nesting was found at those sites. We believe that neither fledgling census was significantly biased by young pelicans capable of flight having left or entered the area. Schaller (1964) observed that primaries erupted in young at 33 d, all young joined one large social group at 50–60 d, and the first flight was attempted at 71 d. Hall (1925) reported first flights, none of which were sustained, at 62–64 d. Our surveys were made 57 and 72 d after June 1, the earliest date that young would likely be hatched, given the mean dates for return of adults to Lavallée Lake. Certainly most fledglings would be incapable of leaving the lake until late August.

Considering the total count of 2067 fledglings in 1975 we believe that the nest estimate of 1293+ was much lower than the correct figure. The number of chicks fledged per nest attempt is unpredictable because of several mortality factors (Schaller 1964; Hosford 1965; Evans 1972; Strait 1973; Knopf 1975). Over an 11-yr period at Molly Islands, 0.4 to 1.2 chicks were fledged annually per nest attempt (Diem 1979). In most cases therefore, one would find a nest population larger than the number of fledglings.

Sub-colony Distribution

There has been considerable variation in location and number of sub-colonies in the study area over the years, according to historical records and aerial photographs (Figure 3). Williams (1928) reported large numbers of White Pelicans nesting on two islands at Lavallée Lake. Ben Ferrier reported nesting on Pelican, Rocky, and Gull islands in 1938 (PANP File 300, 26 September 1938). Nesting was observed on three islands by W. Van Der Sleen in 1939 (letter to the Superintendent, PANP), and by Soper (1952) during a reconnaissance of the park in 1940. Ferrier, Van Der Sleen, and Soper all indicated only one massive sub-colony on Pelican Island, which was still the case in 1947 as indicated by Royal Canadian Air Force air photographs.

B. Greyell (1968. Preliminary park inventory and interpretation plan, PANP. Unpublished report, Parks Canada, Winnipeg. 31 pp.) reported nesting only on Pelican Island in four large sub-colonies within the untreed western half. Nests were first observed in the treed area on Pelican Island by R. Isbister (CWS, personal communication) and E. Boeker (personal communication) in 1971. Our surveys also showed that nesting was restricted to the largest island and some sites shifted between years (Figure 3).

Nesting-area shifts over time have been reported for other White Pelican breeding grounds in North America by Hall (1925), Sugden (1927), Bond (1940), Lies and Behle (1966), Knopf (1975), and Diem (1979). Few explanations for this phenomenon have been put forward. A complex of factors may be responsible, including synchronous breeding behavior where a few birds attract many others to a site (Schaller 1964; Knopf 1975), weather factors and the need for shelter (Diem 1979), fluctuating water levels (Evans 1972; Diem 1979), or disturbance by predators, both avian and mammalian, and by man. Van Der Sleen reported approximately 30 Herring Gull nests on Gull Island along with the White Pelicans. In 1975 Gull Island was entirely occupied by a large colony of gulls (*Larus* spp.) numbering 200+ nests as determined from the aerial photograph survey, which may cause avoidance by White Pelicans.

Extent of the Foraging Grounds

During the survey of 25 July 1975 only 47 pelicans were seen on lakes within the park (Table 3). Observations during 22–24 July indicated very few adults at

TABLE 3—White Pelicans observed at water bodies in the area of Prince Albert National Park during three aerial surveys. — indicates not included in the survey

	Number of pelicans seen					
	27 July 1975		31 July 1975		22 July 1976	
Water bodies	On water	In flight	On water	In flight	On water	In flight
Wasaw, Wabeno, and Wassegam lakes	2	1	8	0	0	0
Tibiska Lake	23	0	20	0	0	56
Paquin Lake	—	—	11	0	0	4
Crean, Hanging Heart, Kingsmere, Bagwa, Lily, Clare, and Waskesiu lakes	10	0	—	—	—	—
Namekus, Trappers, and Halkett lakes	0	0	—	—	—	—
Kiyam Lake	0	0	0	46	—	—
Amyot Lake	7	4	31	0	0	0
Subtotal[1]	42	5	70	46	0	60
Montreal Lake	—	—	267	0	145	98
Montreal River	—	—	10	0	9	4
Bittern, Birchbark, Torch, and Candle lakes	—	—	1	0	5	9
Weyakwin Lake	—	—	28	0	12	19
Listen and Phillion lakes	—	—	—	—	2	2
Smoothstone River (between Clarke lakes)	—	—	—	—	6	16
Clarke lakes	—	—	—	—	14	12
Smoothstone and Swan lakes	—	—	—	—	13	23
Davies Lake	—	—	—	—	13	0
Moosiwu Lake	—	—	—	—	27	8
Molanosa Lake	—	—	0	0	0	0
Meeyamoot and East Trout lakes	—	—	—	—	9	5
Nipekamew Lake and River	—	—	—	—	8	4
Lac La Ronge	—	—	—	—	4	4
Egg and Sikachu lakes	—	—	—	—	12	23
Subtotal[2]	—	—	306	0	279	227
Time	07:45–09:30 CST		06:21–09:24 CST		04:35–08:13 CST 10:10–13:54 CST	

[1]Within Prince Albert National Park.
[2]Not within Prince Albert National Park.

Lavallée Lake except during the period 11:00–14:00 CST each day when the young were fed. All incoming and outgoing flights of adults at that time indicated foraging either to the east or east-northeast of the colony. Consequently, the aerial survey of 31 July 1975 was extended to areas beyond the park boundary in those directions to identify foraging sites.

During this more extensive survey 306 adults were observed outside the park and 116 within (Table 3). The greatest concentration was at Montreal Lake 52 km east of the colony. In-park use was unequal, with 77 pelicans sighted in the extreme southwest corner of the park (Amyot and Kiyam lakes) and 39 in the northeast quadrant. We suspect that the sightings at Amyot and Kiyam lakes represented non-nesting juveniles, as suggested by Soper (1946. Faunal investigations in Prince Albert National Park, Saskatchewan. Unpublished report, Canadian Wildlife Service, Edmonton. 32 pp.), rather than adults from the Lavallée Lake colony, and we concluded that most foraging in the park by breeding birds occurs at lakes in the northeast quadrant. Lavallée Lake was not used for foraging during the breeding or fledging periods.

Another survey on 22 July 1976 also showed most foraging taking place beyond park boundaries, in a semi-circle of minimum distance 52 km N and E of Lavallée Lake and mostly in the Montreal Lake region (Table 3).

White Pelicans foraging off islands in Great Salt Lake, Utah, travelled up to 50 km to summer foraging grounds (Behle 1958). The expanse of Great Salt Lake had to be traversed before productive feeding sites could be reached. No other reports of distances to foraging grounds in America have been reported.

Colony Status

In contrast to other White Pelican colonies (Vermeer 1971; Roney 1978), colony size at Lavallée Lake has apparently increased over the years and sufficient young are fledged to maintain numbers. There is little doubt that this situation reflects the almost complete protection from human disturbance possible for a location in a national park. Continued population monitoring is urged, particularly since human encroachment on the summer foraging grounds is imminent.

Monitoring should be based on an annual fledgling count because that appears to be the least biased indicator of colony status. Late July is the best time for a fledgling census if one is to avoid the occurrence of adults in company with young (Schaller 1964) and the possibility of missing precocious individuals. Aerial surveillance of nesting success has many limitations, but it seems to be the best means of determining approximate nesting intensity and location. Annual surveys are needed because breeding success at other North American pelican colonies has been shown to be "boom or bust" from year to year. Best results on fledgling counts can be obtained with a motorized 6×6 cm format, single-lens reflex camera system which provides optimum image resolution, but does not sacrifice easy operation under hand-held conditions in an aircraft. Nest reconnaissance should employ a camera system with 22×22 cm format.

Acknowledgments

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Behavior in a Non-breeding Bald Eagle

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From 18 May to 21 June 1978 at Besnard Lake, Saskatchewan, a 4-yr-old Bald Eagle (*Haliaeetus leucocephalus*), marked as a nestling there in 1974, was observed for 106.7 h. The bird, in adult plumage, took up residence in a small area of Besnard Lake unoccupied by breeding adults but with five pairs of nesting eagles within 7 km. Most of the marked eagle's time was spent perching, with only relatively small proportions in flapping, gliding, or soaring flight. The amount of time spent soaring and/or gliding increased with higher winds and during the middle of the day. Gliding occurred along shorelines where onshore winds produced updrafts. High perches were used as lookouts, while low perches were used for eating or roosting. The selection of high perches varied according to the position of the wind and the sun; the eagle was observed to fish at an area where oncoming waves swept across an expanse of open water. The eagle was seen to catch a fish on average once every 16 h, though the actual frequency might have been somewhat higher. Most interactions between the marked eagle and other eagles, including calls and flights, were friendly or only mildly antagonistic.

Key Words: Bald Eagle, *Haliaeetus leucocephalus*, territory, behavior, non-breeding, wing-marking, Saskatchewan.

There is little known about the activities of eagles after fledging and before nesting (Brown 1955; Brown and Amadon 1968). Our data on Bald Eagles (*Haliaeetus leucocephalus*) raised in Saskatchewan, show they migrate south to the western half of the United States, with many returning to spend their summers as subadults at or near the lake where they were raised (Gerrard et al. 1974, 1978). In the first three years, birds do not remain in any one area for more than a day or two (Gerrard et al. 1978), but at some time there must be a change from the wandering adolescent to the territorial adult. The age at first breeding can be expected to vary (Lack 1966), and at least some non-breeding eagles are probably in full adult plumage. In 1978, we had a rare opportunity to determine the daily activities of a Bald Eagle in its first year of adult plumage, and its interactions with neighboring eagles.

The markers present on this bird in 1978 tell us that this eagle is one of five originally marked at four nests on Besnard Lake in 1974. The nests are all between 4.3 and 17.7 km from perch 1 (Figure 1). What was probably the same bird was previously sighted after fledging as follows: (1) 22 and 23 November 1974, Fort Peck, Montana; (2) 28 June 1976, Mercer Lake, Saskatchewan, 10.4 km SW of perch 1; (3) 2 August 1976, Besnard Lake, Saskatchewan, 10.8 km SSW of perch 1; and (4) 5 July 1977, Besnard Lake, 3.8 km NW of perch 1. In 1978, the marked eagle was in full adult plumage but at close range a few small light brown spots were visible in the head and tail, and a few flecks of white showed in the breast and under the wings.

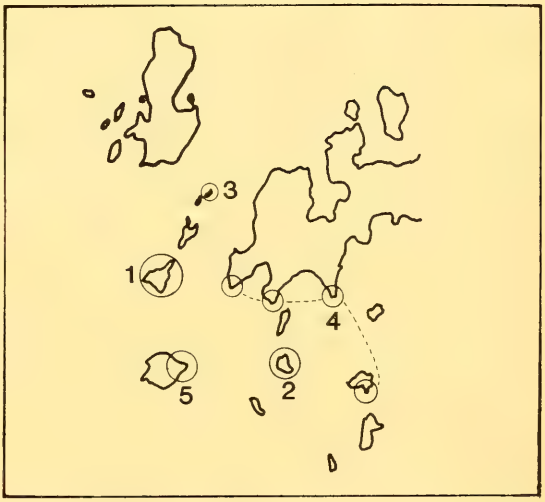

FIGURE 1. A diagram of the marked eagle's territory and major high perch sites. A numbered perch may represent more than one tree at the location shown. Perches used most frequently (1 and 3) had the highest coniferous trees within the area, with the exception of trees far from the water on the large island north of site 2. Islands not used for perching (e.g., the island just northeast of 1, and the two islands near 2) had lower trees or deciduous trees.

Methods

We watched the marked eagle from the shore 0.1–0.5 km away, or from a boat 0.1–0.3 km away. Most observations were made from the boat, which allowed us to follow flights more easily. Individual flights were timed with a stopwatch. Temperature, wind speed, wind direction, cloud cover, and thermal activity were noted hourly. We use the term home range to refer to an area surrounding the nest used by nesting adults. The term territory refers to that part of

the home range which was defended, the limits of a territory as discussed here being the farthest points at which the presence of an intruder provoked a chase. Statistical comparisons of the proportion of time soaring and gliding with varying wind speed and time of day were made using the Mann-Whitney U test.

Results

Daily Activity Pattern

In 1978, the marked bird was first seen 18 May, perched on the top of a broken-off spruce termed perch 1 (Figure 1) on a small island. It was last seen 21 June on this same perch. We spent 127.9 h on 24 d watching for this bird and kept it in sight for 106.7 h, or 83.4% of the time watched. Because it left its roost at approximately 04:00 and returned near 22:00, observations were divided into six 3-h intervals (Table 1). Of the time we kept the eagle in sight, it spent 94% of the time perching, 2.4% in flapping flight, and 3.5% in soaring and/or gliding flight. We evaluated separately a 24-h period when the eagle was followed continuously. On this occasion, it spent a similar proportion of its time from 04:00 to 22:00 perching (94.7%), slightly more flapping (3.4%), and slightly less soaring and gliding (1.9%). The winds were only 11–18 km/h that day, however, and the one fishing attempt from high soaring flight was successful quickly (23 min); thus, the amount of soaring and gliding might have been lower than average. Nevertheless, the observations from this one day suggest that our overall figures are representative. The proportion of time spent in flapping flight was relatively constant throughout the day, whereas the time spent soaring and gliding fluctuated markedly with a peak of 9.0% between 13:00 and 16:00. The proportion of time spent soaring and gliding also fluctuated in association with changes in wind speed (Figure 2). Soaring and gliding occurred more than 5% of the time with winds of 15 km·h^{-1} or

TABLE 1—Activity pattern of the marked Bald Eagle

	Time (in %)			Total
Hours	Perching	Flapping flight	Soaring and gliding	time watched (min)
04:00–07:00	96.3	3.3	0.5	711
07:00–10:00	93.7	2.1	4.1	1526
10:00–13:00	93.8	1.3	4.8	1221
13:00–16:00	87.6	3.5	9.0	1084
16:00–19:00	94.9	2.6	2.5	954
19:00–21:00	97.5	2.0	0.5	866

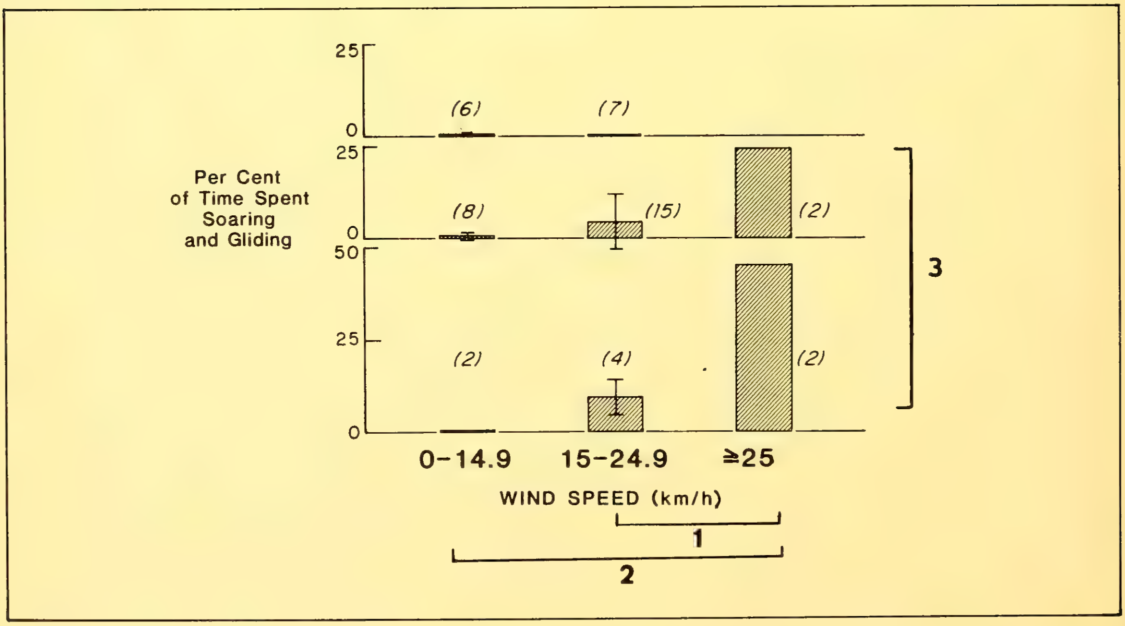

FIGURE 2. The influence of wind speed on the percentage of time spent soaring and gliding. Because time of day was such an important variable, observations were grouped into three time periods with similar proportions of time spent soaring and gliding. Top, 04:00–07:00 and 19:00–22:00; middle 07:00–13:00 and 16:00–19:00; bottom 13:00–16:00. Square brackets indicate significant differences: 1, $P < 0.05$; 2, $P < 0.01$; 3, $P < 0.05$ (only data with wind speeds > 15 km·h^{-1} were compared).

more from 13:00 to 16:00, and with winds of 20 $km \cdot h^{-1}$ or more from 7:00 to 13:00 and 16:00 to 19:00.

Type and Location of Perches

On the two occasions when the marked bird was seen to roost, it flew to a low sheltered perch about 40 m in from the shore; during the day this roosting perch was not used. Of 100 h that we saw the eagle on daytime perches, 86.4 were spent on high perches and 13.6 on low perches. High perches, 15–40 m above the water at the tops of conifers, were used for fishing or general observing. The eagle preferred high perches in trees that rose above neighboring foliage providing a wide view which faced into the wind (Table 2). The territory used by this bird (about 4 km^2) is outlined by its major high perch sites (Figure 1). Perch 1 was used predominantly with west winds, perches 2, 4, and 5 primarily with south and southeast winds, and perch 3 mostly with northeast winds.

The time of day also influenced perch use, presumably reflecting the changing position of the sun. With south and southeasterly winds, perch 2 on the east side of the south bay was used in the morning and in the early afternoon when the sun was in the east or high in the south, while perch 5 on the west side of the south bay was used exclusively in the afternoon and evening when the sun was in the west. With northeasterly winds perch 3 was used only in the afternoon when the sun was in the southwest. In contrast, this same perch when used in west winds (fishing looking to the west) was also used in the morning when the sun was in the east.

Location of Flight Paths

The location of glide pathways (Figure 3) and thermals appeared to influence the flight routes chosen by the eagle. Gliding, except in association with high soaring flight, occurred almost exclusively along shorelines where winds sweeping across the lake created updrafts on meeting the trees along the shore. The eagle sometimes began gliding in such a shoreline updraft and then gradually gained several hundred metres in height in a thermal, suggesting that such sites might also have been sought out as potential sites of thermals. In addition to flights within its home range, the eagle also flew outside this area. We were less successful in following these long flights. Where the eagle was probably but not definitely the marked one, we have put a question mark in Figure 3. The eagle sometimes drifted downwind on such flights; however, there were exceptions, and on three afternoons with northwesterly winds the eagle took advantage of particularly good thermal conditions to go north or northwest upwind.

TABLE 2—Influence of wind direction on perch use by the marked eagle

Perch	Direction faced[1]	Time perched (%) at wind directions: S and SE (1480 min)[2]	SW,W,NW (2662 min)	NE (516 min)
1	W	7.3	88.6	70.8
2	S	50.8	0.4	0
3	NE	0	6.4	29.2
4	S	16.7	0.6	0
5	S	13.0	1.3	0

[1] Major direction the perch faced towards an expanse of open water.

[2] Total time the marked eagle was on high perches with each wind.

Fishing

We saw the eagle catch fish eight times. Five times it flew directly from the top of a conifer to catch a fish which was within about 0.2 km. Three times, the eagle had been flying (once soaring high and twice cruising fairly low over the water) when it flew down to the water to catch the fish. After a successful fishing expedition, it always flew to a low perch to feed. These perches were less than 10 m above the water and were well below the level of neighboring tree-tops. Four of these perches were on branches of Trembling Aspens (*Populus tremuloides*) overhanging the water, two were on large rocks, one on the side of a small spruce near the shore, and one on a sandspit. The eagle spent an average of 5.2 min eating (range 1.0–10.5 min). After finishing its meal, the eagle remained on the low eating perch for an average of 59 min (range 0–181). Only once did it land on such a low perch without a fish, and that was after an unsuccessful fishing attempt. The mean catch was one fish for every 16 h we watched, but we suspect that other fish were caught. Several times the eagle flew out of sight and was found 10–20 min later perched low. If these represented successful fishing attempts, the eagle might have caught a fish as often as once every 8 h. Indeed, during a period when the eagle was followed for 26 h continuously, three fish were caught, for an average of one every 6.3 daylight h.

Relationships to Other Eagles

There were five nesting eagle pairs in the vicinity of the marked bird's range in 1978 and they raised young as follows: "J" — three young, "M" — one young, "B" — three young, "D" — two young, and "T" — one young. Figure 4a and b shows the home ranges of these eagles as observed 18 May to 23 June on easterly and westerly winds. Neighboring birds shifted their flights depending on the wind. With easterly winds, the marked bird was visited by "T" eagles from the

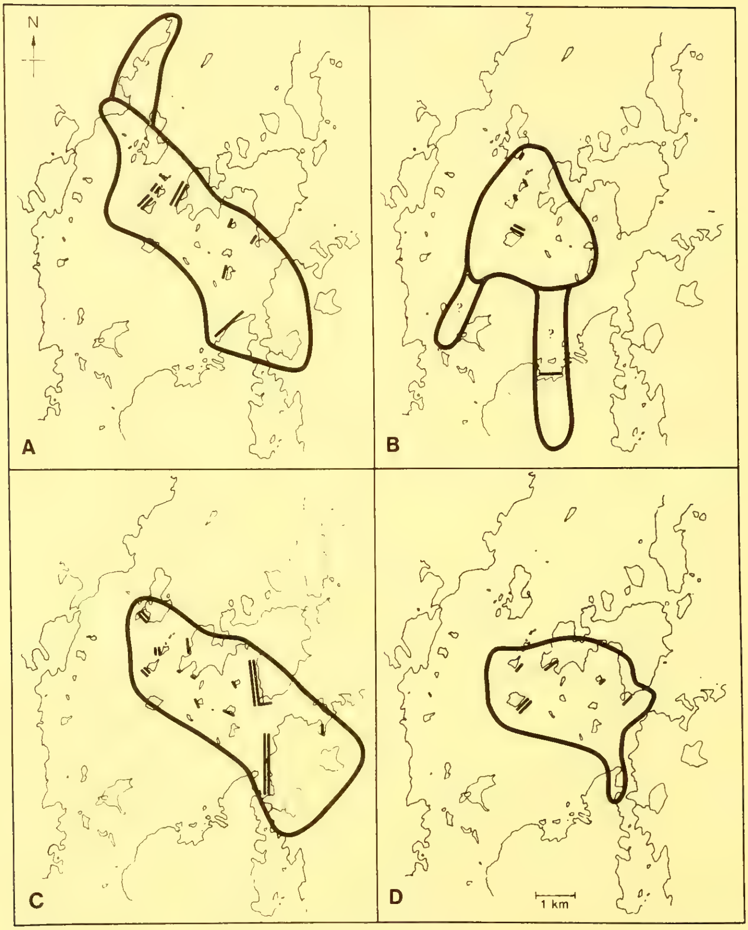

FIGURE 3. Home-range utilization with variation in the wind direction. For each wind direction, major glide pathways (solid lines) are shown. Those glide pathways which were used most (three or more occasions, or for more than 10 min total) are shown with a double line. A, winds W to NNW; B, winds N to ENE; C, winds S to WSW; D, winds E to SSE.

east and with westerly winds it was visited by "J" eagles from the west.

The presence of a visiting eagle almost always evoked a reaction from the marked bird, though it did not usually attack. Rather, when visiting birds flew into its territory (at distances of up to 2 km from the marked bird), it usually called, and sometimes flew toward the intruder (Table 3). When the visitor perched some distance (1.0–2.5 km) from the marked bird but within its territory, it invariably flew toward the visitor and either perched nearby, or displaced the visitor from its perch, causing the intruder to move a short distance to another perch.

On four occasions a visitor flying nearby reacted to the calling of the perched marked adult by flying in to perch nearby, suggesting to us that the position and calling of the marked eagle may have attracted the visitor. On these four occasions, and two others when it was perched near a visitor, the marked bird was the larger one, suggesting it was a female. Two further observations of behavior suggested courtship or preliminaries to pair-bond formation. Once, when the marked bird was perched next to another adult, it adopted a posture identical to a copulation solicitation posture (Gerrard et al. 1979), though no copulation occurred. Once, a bird in its 3rd year (by plumage) that had been perched on a nearby tree, repeatedly soared and glided over the island with much diving and stooping similar to a courtship display. At intervals, this 3rd-yr male (by size) came down to perch beside the marked bird. They then called at one another and on occasion gently pecked

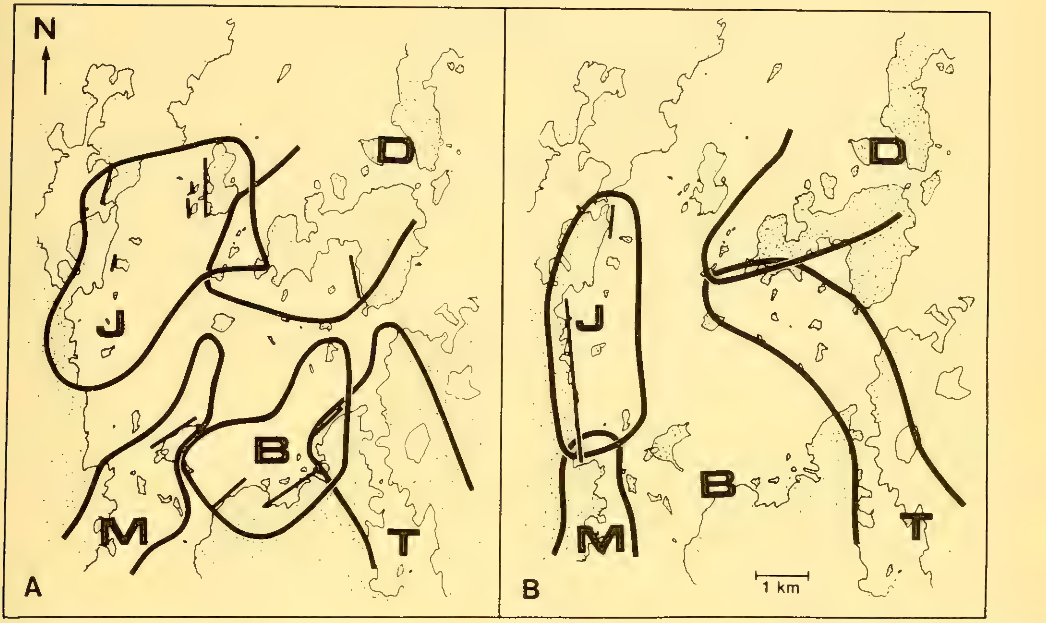

FIGURE 4. Home ranges of nearby eagles. Parts of the home ranges near to the territory of the marked eagle are based on more observations than those parts further away. A — winds with any westerly component, B — winds with any easterly component. Glide pathways used by these eagles are shown by solid lines.

each other's bills. These two birds eventually flew off at nearly the same time, and were lost to view. At 04:30 the next morning when observations were resumed, the marked bird was again perched beside what was assumed from its plumage to be the same bird. The visitor again soared and glided as before, then perched, first in a nearby tree and then beside the marked bird. At 05:56 an adult arrived from the direction of nest D, dived at the 3rd-yr bird, and pursued it closely until it left the area for good. The adult paid no attention to the marked eagle though the latter called loudly when the chase began, and later when the former again flew over the island returning toward nest D.

The marked bird almost always managed to avoid flying near other eagle nests. Long flights outside its usual range went between two nearby territories rather than through the middle of either one. The marked eagle did, however, visit the edge of nearby territories three times, being driven away twice and once flying away quickly on the arrival of the territorial adult.

Discussion

The daily activity pattern of the marked eagle probably reflects in part adaptation to changing weather conditions. We suggest that the increases in soaring and gliding toward the middle of the day or with higher winds reflect the influence of the sun and the temperature on thermals and the contribution of winds to shoreline updrafts. These conclusions are in agreement with those of Brown and Amadon (1968) that birds with a low wing loading (the ratio of the mass of the bird to its wing area) can soar earlier in the day, while those with a high wing loading (e.g., eagles) usually need to wait until near midday and/or for strong winds in order to begin soaring and gliding. Female eagles have a higher wing loading than males (Brown and Amadon 1968) so would need stronger thermals to begin soaring. Although the marked eagle did not begin soaring until winds were more than 15 km · h^{-1} from 13:00 to 16:00 and higher than this earlier or later in the day, we saw other eagles soaring with less wind. Our suspicion, based on size and social behavior, that the marked bird was a female would therefore fit with the observations of its soaring pattern. The relatively small proportion of time spent in flapping flight throughout the day may reflect a relatively high metabolic cost of such flight to Bald Eagles.

Weather influenced not only the type of activity, but its location. As mentioned in previous studies (Whitfield et al. 1974; Gerrard et al. 1975), wind influenced individual flight paths, and even the shape of

TABLE 3—Interaction of the marked eagle with other eagles that entered its range

Position of the intruder eagle when first seen[1]	Response of the marked eagle		Outcome of the interaction
Perched within the marked bird's basic range (3/2)[2]	Flew toward the intruder (3/2)	Landed in a nearby tree (1/0)	The intruder flew off. The marked eagle followed behind, until the intruder reached the boundary, and then it perched, but continued to watch in the direction the intruder went (1/0)
		Flew straight at the intruder, then landed where the intruder had been perched (2/2) with calling[3] on two of these occasions	Intruder flew off (0/1)
			Intruder flew, circled, and then landed on a nearby perch (1/1)
			Intruder shuffled sideways allowing the marked eagle to land beside it and the two continued perching together with some calling at one another (1/0)
Flying within the marked eagle's basic range (8/5)	Remained perched (6/3)	Called[3] at the intruder (6/2)	The intruder flew in to perch near the marked eagle (3/1)
			The intruder left the area (3/1)
		No calls heard (0/1)	The intruder left the area (0/1)
	Flew toward the intruder (2/2)	Called[3] at the intruder (1/1)	Intruder did not leave the area immediately and was chased by the marked eagle (1/1)
		No calls heard (1/1)[4]	Intruder left the area before the marked eagle got near it (0/1)
			Intruder was soaring at NE edge of the marked eagle's range in favorable updrafts. The marked bird joined it and they soared together (1/0)
Flying within the marked eagle's basic range and caught a fish (2/0)	Chased rapidly after the intruder (2/0) calling at it before flying on one occasion		The intruder flew rapidly out of the area, in one instance needing evasive flying to avoid being caught by the marked eagle (2/0)

[1]Only includes interactions where initial position and response were observed.
[2]No. of adults/no. of immatures.
[3]These calls were the "ye-ha-ha ye-ha-ha ha-ha-ha" of Retfalvi (1965).
[4]Calling could have been missed owing to observer position and wind.

the home range. Perch sites facing into the winds coming across an open stretch of water may have been chosen so that the waves could carry dead or injured fish toward the waiting eagle. The glare of the sun's reflection on the water could be a significant impediment to the eagle in sighting its prey, and indeed perch sites changed with the time of day so that the eagle was not facing the sun.

The marked eagle kept a close watch for other eagles entering its territory, and indeed its high perches may have been chosen to offer a superior view of the area and to make itself more visible to intruding eagles. We were aware of only one eagle, which came within 1.5 km of the marked bird when it was in its territory, to which it did not react either by calling or flying, and on that occasion the calling could have

been missed. This suggests that the marked eagle was acutely aware of other birds, and reacted quickly to their presence. Vigorous chasing of intruders occurred only when they caught fish within the eagle's territory, however, and most eagle–eagle interactions appeared friendly or only mildly antagonistic. Occasions when the marked bird perched near another eagle may have represented a desire of one eagle to associate with another, and one or two observations suggested that early courtship or pair-bond formation might be occurring.

Our observations of this bird and nearby pairs show that nesting Bald Eagles in northern Saskatchewan are clearly territorial and use ranges of about 10–15 km². This size should be taken as a minimum since we did not set out to determine it accurately in this study. A considerable proportion of the home range is actually defended, about 6 km² in the case of the nest "J" territory where we have the most data. This can be compared with Florida and Michigan where Bald Eagles have been found to defend territories of 1.5–2.0 km² (Broley 1947; Mattsson 1974). From our observations, it would appear that the location of nearby breeding pairs is soon learned by non-breeding adults and their territories are avoided. In one curious instance during the present study, a territorial adult vigorously chased away a smaller eagle which appeared to be displaying to the marked bird. One possible explanation is that the territorial male eagle defends a limited part of its range against all eagles and a larger part against males.

We do not know why the marked bird left its territory on 21 June. We watched the area intensively for the next 2 d and checked it intermittently later in the summer without seeing the bird again, though the next summer (1979) it was seen once in the company of another adult 10 km southwest of perch 1. Because we did not see its departure, the bird might have been chased away. A hard chase by a nearly adult bird in late May had failed to drive it out of the area, however, so we suspect that a single chase probably would not have been sufficient to cause its departure if the area had continued to be desirable. Alternatively, a decrease in food availability may have contributed to its leaving. The young in nearby nests were growing rapidly, and banding visits to four of these in the few days before 21 June revealed no fresh food in any. The marked eagle had been watched from 05:30 till it roosted for the night on 20 June except for three periods totalling 122 min, and from 06:30 till 10:00 the morning of 21 June. It caught no fish during this time, and only once, at 08:32 on 20 June, was it found on a low perch typical of a feeding perch, suggesting it might have just eaten. Unsuccessful fishing flights were seen late in the day on 20 June. We suspect that fish were harder to find, perhaps in part owing to local conditions and in part to heavy fishing by nearby territorial adults to feed their young.

Acknowledgments

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Observations of Loons (*Gavia immer* and *G. stellata*) at a Bog Lake on the Queen Charlotte Islands

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A small muskeg lake on the Queen Charlotte Islands was frequented in summer by up to 59 Common Loons (*Gavia immer*) and 19 Red-throated Loons (*G. stellata*), mostly non-breeding adults. The former occupied the deeper or central areas of the lake and were most abundant near mid-day, while the latter preferred the shallows and were present from early evening until dawn. Although interactions between the two species were rare, Common Loons were dominant to Red-throated Loons except when the latter were close to shore. During peak abundance, Common Loons congregated in large groups; Red-throated Loons usually occurred in pairs. Common Loons used the lake primarily for foraging, with peak activity in mid-morning and at dusk; the dominant fish species present was Threespine Stickleback (*Gasterosteus aculeatus*). Red-throated Loons obtained much of their food during daily visits to the ocean and foraged only intermittently on the lake. Dive durations in shallow water were approximately 30 s for both species and, in open water, 40 s for Common Loons.

Key Words: Common Loon, *Gavia immer*, Red-throated Loon, *Gavia stellata*, Queen Charlotte Islands, seasonal abundance, diurnal movement, foraging, Threespine Stickleback, *Gasterosteus aculeatus*.

The Queen Charlotte Islands are one of the few areas in western Canada where Common Loons (*Gavia immer*) and Red-throated Loons (*G. stellata*) overlap in their summer distribution. The Common Loon is at the western edge of a continuous range, extending across Canada south of the 60th parallel and north into the Yukon and Alaska. The Red-throated Loon on the islands occupies one of the few southerly breeding areas, their principal range being coastal regions from Alaska to Labrador (Godfrey 1966).

Reproductive biology of loons has received considerable attention (Munro 1945; Sjolander and Agren 1972; McIntyre 1975; Davis 1972; Bundy 1976), yet the activities of non-breeding adults on freshwater are not well known. At a bog lake on the Queen Charlotte Islands, we were able to observe both species and to detail some aspects of their life histories. This study documents seasonal and diurnal movements, habitat preferences, grouping patterns and foraging activity. Other aspects such as vocalizations, behavioral displays, and reactions to predators will be reported separately.

Study Area

Drizzle Lake (53° 56′N, 132° 05′W) (112 ha) is one of several small lakes in an expanse of muskeg and coniferous forest in the northeast corner of the Queen Charlotte Islands (Figure 1). A large marine inlet lies 2.5 km to the west and open ocean is about 15 km to the north and east. Although winter temperatures are moderated by proximity to the ocean, the lake occasionally has ice cover in December and January. The Drizzle Lake watershed was established as an ecological reserve in 1971, principally for its unusual population of stickleback (*Gasterosteus aculeatus*) (Moodie and Reimchen 1973) and as a representative muskeg area on the Queen Charlotte Islands (Krajina et al. 1978).

Surrounding vegetation includes stands of conifers including Western Red Cedar (*Thuja plicata*), Lodgepole Pine (*Pinus contorta*), and Western Hemlock (*Tsuga heterophylla*), a dense understory of salal (*Gaultheria shallon*), and open areas of *Sphagnum* muskeg. The lake is fed by a stream that drains the adjacent bogs; this results in a deep red staining to the lake, and a corresponding reduction in light penetration (maximum 2 m). Littoral vegetation is sparse and includes *Nuphar luteum*, *Juncus* spp., and *Lilaeopsis occidentalis*. Macro-invertebrates include trichopteran larvae and occasional odonate nymphs. Four species of fish are present, Threespine Stickleback, Cutthroat Trout (*Salmo clarki*), Dolly Varden (*Salvelinus malma*), and juvenile Coho Salmon (*Oncorhynchus kisutch*).

Methods

Records of bird activity were maintained from July to November 1977, and from January to November in 1978 and 1979. From May to August, observations were made on average 5 d per week, from dawn to 09:00, from 19:00 to dusk, and at irregular intervals throughout the rest of the day (weather permitting). In early spring and in fall, shorter day lengths restricted

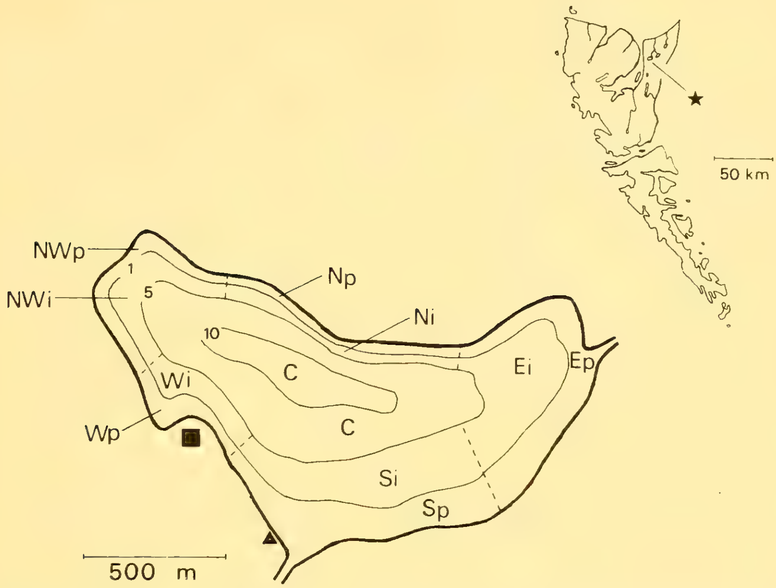

FIGURE 1. Study area. C = center, i = intermediate, p = peripheral. N, S, E, W, NW indicate compass directions. Inset —Queen Charlotte Islands. ■ = observation platform, ▲ = observation blind. Depth contours in metres.

evening observations. Loon activity, including numbers, positions, movement and diving, was recorded on standardized data cards. For recording positions of loons, the lake was visually divided into 11 areas, according to depth (assessed by lake transects) and compass direction (Figure 1). Four small floats were anchored in the southeast and northeast areas of the lake to mark the 1-m and 5-m depth contours. The majority of observations were made with a 20- to 45-power spotting scope from an elevated 4-m platform, allowing visual coverage of 97% of the lake surface. In July and August 1979, observations were made from a blind in the southern corner of the lake, adjacent to a nesting pair of Red-throated Loons. To determine age classes of loons, we observed plumage patterns and bill color at close range with the spotting scope and compared these with descriptions by Palmer (1962). Diving durations were timed to the nearest second.

Distributions of fish were assessed by standard mesh minnow traps, seine, and gillnets (mesh size 13, 25, and 89 mm) at monthly intervals from April to November. Species and length of captured fish were recorded before they were released.

Results

Abundance and Description

Both loons occurred on the lake from April through August, with similar patterns of abundance during the 3 yr of observation (Figure 2). Red-throated Loons (RT) arrived first (29 March 1978, 27 March 1979), their numbers increasing throughout April, and thereafter remaining similar (maximum 19) until the middle of August. Individual Common Loons (CO) occurred irregularly throughout April and May. In June, numbers increased sharply, reaching a maximum (59) in late July, and declined rapidly in August, with occasional birds until November. Peak numbers occurred between 18 July and 25 July in all 3 yr, and in each year this concentration of individuals remained for only 2 d.

All RT, except for a single chick raised on the lake in 1979, were in definitive alternate plumage (at least 2 yr old). As well, CO in spring and summer had reached full adult plumage (at least 3 yr old), although about 10% had a slight mottling of the lores and a reduced expression of the frontal neck band, presumably indicating an incomplete pre-nuptial molt. Both species were in breeding plumage, but only RT nested, one pair in 1977 and 1979, and none in 1978.

RT and CO differed in diurnal patterns of movement (Figure 3). Throughout spring and summer, the majority of RT left the lake from 1 to 3 h after dawn and flew west to the marine inlet. This destination was confirmed by intermittent observations mid-way between the lake and the ocean; they called continuously in flight and could be heard from at least 1 km away. They returned to the lake along similar flight paths,

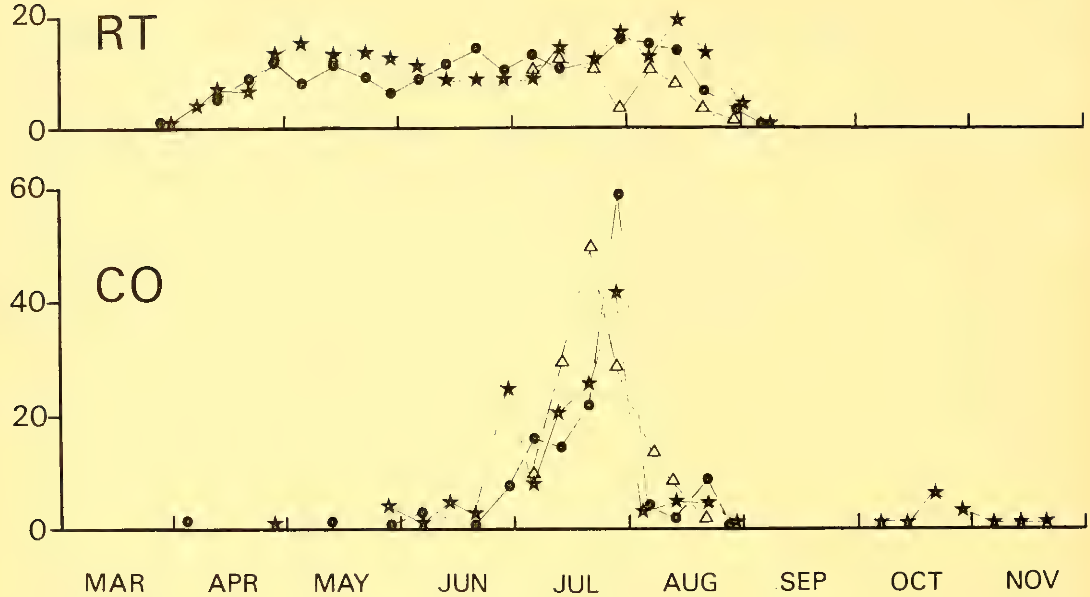

FIGURE 2. Maximum daily numbers of Red-throated Loons and Common Loons on the lake at weekly intervals. △ = 1977, ● = 1978, ★ = 1979.

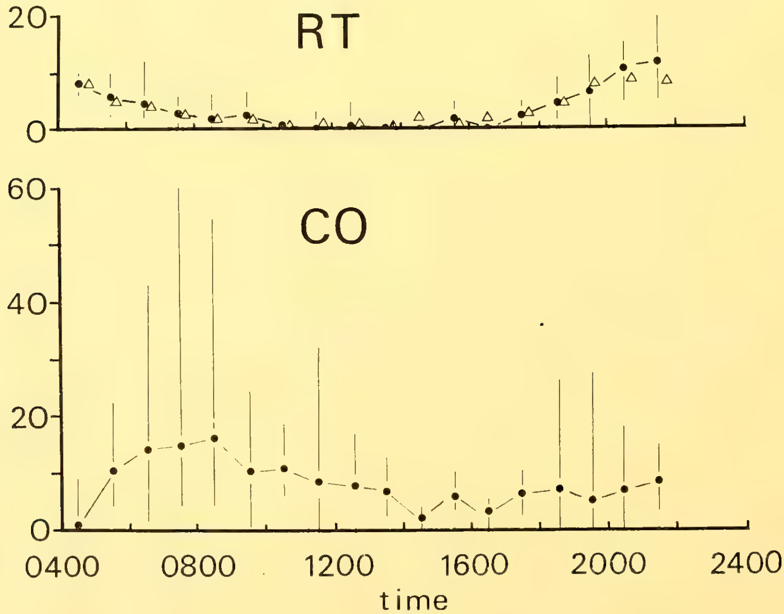

FIGURE 3. Mean number of loons on the lake at hourly intervals (PST). Data averaged for all years. Vertical line indicates 1 SD. △ = Red-throated Loons in April and May; ● = Red-throated Loons in June, July, and August; ● = Common Loons in July.

TABLE 1—Surface distribution of loons. Mean percentage for all loons recorded 1977–1979. Lake areas as in Figure 1

Species		Percent of sightings by area						No. of loons recorded
		NWp&i Wp&i	Np&i	Ep&i	C	Sp	Si	
Red-throated Loon	Mean	6.5	4.1	3.0	17.4	16.6	52.4	1934
	SD	3.3	1.3	3.8	8.8	7.3	4.0	
Common Loon	Mean	44.9	3.5	8.7	29.2	4.8	8.9	1723
	SD	6.6	3.0	1.9	10.1	4.5	7.9	

beginning about 3 h before sunset, and remained on the lake overnight. In August, individuals remained for longer periods in the morning, departing 1–6 h after dawn, but still returned before dusk.

Diurnal movement of CO was less regular. In April and May, they departed shortly after dawn and returned in the evening, similar to RT. From June to August, however, most CO arrived in the morning (06:00–09:00) and departed before dusk, with peak numbers occurring at mid-morning. Departing loons flew west towards the marine inlet and also southeast, in the direction of other small lakes. Distinct from this daily pattern of movement, two CO, in either second year or definitive basic plumage, remained on the lake continuously in October and November 1979.

Distribution on the Lake

RT and CO frequented broad zones that differed in water depth and bottom profile (Table 1). RT principally occupied the expansive shallows of the southeast. Pairs were occasionally observed 200 m up the inlet stream. CO were observed throughout the lake but were most frequent in the northwest and central areas. During strong winds, CO concentrated in sheltered areas of the lake, whereas RT tended to remain in the southern area, irrespective of wind direction.

RT did not move extensively around the lake in daylight. Upon arrival in the evening, the majority landed in Si[1] and remained there until dusk. At this time, two or three pairs often dispersed into peripheral regions along the south and west shores. In contrast, CO moved widely over the lake surface. As an example, on 27 July 1977 the following distributions of CO were noted: 08:05 — 14 Wi, 8 C; 08:10 — 11 Wi, 4 Ni, 7 C; 08:40 — 1 Ni, 3 Ep, 18 Ei; 08:50 — 3 Wi, 1 Ei, 8 C, 8 Si, 2 Sp,[1] representing for some individuals, about 1000 m of surface movement. This example is typical of changes in distribution within short periods.

Group Structure

RT generally occurred in pairs during flight, surface swimming, and diving activity. Of 353 RT arriving or departing (1979), 31% were individuals, 65% in pairs, and 4% in groups of three or more. In April and May, pairs were spatially separated but in June and to a greater extent in July, they coalesced into larger groups (Table 2). These were only loosely cohesive,

[1]See Figure 1.

TABLE 2—Occurrence (%) of group sizes by month for Red-throated Loons. Data on Common Loons includes only sightings in July

Species	Year	Month	Percentage of loons in each group size									No. of loons recorded
			1	2	3	4	5	6–8	9–12	13–18	19+	
Red-throated Loon	1978	Ap/May	8.5	70.5	5.1	9.5	1.7	4.7	0	0	0	295
		June	16.0	27.8	21.5	6.8	4.3	23.6	0	0	0	237
		July	2.5	23.2	8.7	11.6	14.6	14.5	24.9	0	0	251
		Aug	0.9	50.9	8.2	10.9	13.6	6.4	9.1	0	0	110
	1979	Ap/May	8.9	74.9	5.7	2.6	2.1	1.5	4.3	0	0	470
		June	44.4	44.4	11.2	0	0	0	0	0	0	81
		July	12.1	27.3	11.7	12.5	11.8	24.6	0	0	0	256
		Aug	8.1	33.5	6.8	9.3	14.5	16.2	11.6	0	0	173
Common Loon	1978	July	9.4	10.7	6.6	8.8	6.3	16.5	11.0	7.5	23.3	638
	1979	July	12.0	8.5	11.6	8.2	9.0	11.7	18.0	14.4	6.7	778

forming near sunset, and dispersing before dusk. Display, vocalization, and brief flight activity were prevalent within these groups.

CO were more gregarious than RT, with pair associations uncommon. Of 216 CO arriving or departing (1979), 40% were individuals, 16% in pairs, and 44% in groups of three or more (maximum 16). Generally, about half of the CO on the lake occurred in a single group, with the remainder scattered in smaller groups or as individuals (Table 2). During peak numbers in July, aggregations of up to 44 birds were recorded. These large groups were primarily engaged in foraging, and aggressive interactions were rare.

Diving Activity and Prey Capture

Both species foraged in the lake throughout the season, CO more extensively than RT. For all individuals recorded in 1977 and 1978 (RT = 823, CO = 830), 15.2% of RT and 48.1% of CO were diving (chi-square test, $P < 0.001$). RT activity was greatest from 07:00 to 11:00, just prior to their departure from the lake, and again intermittently near sunset. Among CO, it was most extensive from 07:00 to 11:00, least common between 15:00 and 18:00, and increased again towards dusk, often continuing until darkness terminated observations. Spatial distribution of foraging in each species was similar to the general distribution (cf., Table 1). In RT, 70% of all diving was in water less than 1 m deep, while only 15% of CO dove in this region.

In July, when CO were abundant, we observed synchronous diving near shore (10–100 m). For example, a group of 34 birds dove within 10 s of each other and surfaced 20 to 40 s later over a wider area. While some of these individuals dispersed and continued with solitary diving, the remainder merged and dove again synchronously, this pattern continuing for several hours. We observed this type of diving only near shore; in the center of the lake, birds foraged individually or in loose aggregations. We did not see group diving in RT, even when pairs flocked together in June and July.

Mean duration of dives in shallow water was similar in both species: RT, 28.6 s (maximum 43.0, SD = 9.1, N = 36); CO, 30.4 s (maximum 48, SD = 11.9, N = 85). Open-water dives by CO in summer were longer: 41.1 s (maximum 72, SD = 6.2, N = 24).

Prey species in the lake differed in abundance and distribution. Stickleback (10–100 mm) was the only species common throughout the lake, occurring individually or in large schools. The remaining fish species were uncommon, with occasional Cutthroat Trout (200–4000 mm) in surface waters and Dolly Varden (40–100 mm) and juvenile Coho (30–120 mm) in the benthic regions during the day and inshore at dusk. Macro-invertebrates were also uncommon and were restricted to shallow water.

In spring and summer loons swallowed their prey beneath the surface and hence no data on food habits were obtained. In October, however, two CO brought their prey to the surface where it was possible to obtain minimal estimates of capture success and to identify species. Over a 2-wk period, we recorded 187 dives (15–61 per day), the majority of which took place in open water (Wi and C). In total, the loons surfaced with fish in 50.8% of these dives (range 46.1% to 70.4% on different days), and where the fish could be identified (N = 84) the prey was always stickleback (approximate length 50–70 mm). Dive duration averaged 40.6 (maximum 65, SD = 8.4, N = 85) when the loon surfaced without prey and 20.6 s (maximum 38, SD = 5.4, N = 44) when fish were brought to the surface. Manipulation time averaged 18.5 s (SD = 10.0); large dorsal and pelvic spines on these fish must be broken or depressed before they are swallowed.

Interactions

RT and CO were seldom observed within 100 m of each other in open water, the distance being usually maintained by RT slowly swimming away from approaching CO. Occasionally, confrontations occurred when CO encountered RT nearer to shore or in the southern area of the lake. The RT response was usually to fly to another area: this was prefaced by extensive bill-dipping, stretching, or "swim-flying" (McIntyre 1975) directly at the intruding CO. Infrequently, a pair of RT responded with the "plesiosaur race" (Huxley 1923) and associated vocalizations; in such cases, the CO retreated. Aggressive interactions were frequent in the vicinity of the single RT nest. When CO approached within 50 m, the RT, whether on the nest or floating nearby with a chick, dove and attacked the swimming CO from beneath the surface; the CO immediately swim-flew to another part of the lake.

Discussion

There has been a consistent temporal and numerical regularity in RT and CO on Drizzle Lake. RT arrivals in late March and April coincide with occupation of lakes at similar latitudes across their breeding range and are up to 2 mo earlier than at more northerly lakes (Palmer 1962; Dement'ev and Gladkov 1969; Bundy 1976). Presumably the disappearance of ice cover by February allows such early occupation of breeding areas. It is possible that these RT overwinter in British Columbia waters, since those wintering off the western United States begin migrating in April and do not reach Alaskan waters until mid-May (Palmer 1962).

Similarity in numbers from May to August, regularity of evening arrival times and flight paths, and consistency in surface distribution suggest that many

of the same individual RT frequented the lake daily throughout the season. Regular use of lakes by non-breeding adults (possibly 2-yr-old prebreeders) has not, to our knowledge, been documented previously for the species. Bundy (1976), however, refers to congregations of adult RT in spring on the Shetland Islands, where "long inactive periods are spent on larger 'communal' lochs."

Despite the abundance of small fish, RT did not forage extensively on the lake, and presumably did much of their feeding on the ocean, where they regularly spent the day. Movement to the ocean is common for RT that nest on ponds without suitable prey (Bent 1919; Dement'ev and Gladkov 1969; Davis 1972). A RT chick raised on the lake in 1979 was fed only marine fish (Osmeridae and Ammodytidae) in 6 wk of parental feeding (Reimchen and Douglas, unpublished data).

A striking characteristic of CO is the yearly peak abundance for a 2-d period near 20 July. Social flocking in this species within the breeding range has been reported for many areas (Palmer 1962). In southern Ontario, unmated birds and unsuccessful nesters congregated on lakes from mid-May through August (Rummel and Goetzinger 1978), and in Manitoba, groups of 60 to 100 loons foraged on large lakes in June and July (Rand 1948). Flocking has also been observed on lakes in southern British Columbia in May (Munro 1945) and on marine waters in June (Hatler et al. 1978).

In other geographical areas, RT nest on shallow or stained lakes while CO prefer larger and deeper lakes (Cramp and Simmons 1977). The surface distribution on Drizzle Lake, with RT in the shallows of the southeast and CO in the deeper central and northwest areas, corresponds to these generalized habitat preferences. The distribution of RT was generally independent of that of CO, as they occupied the same positions and showed the same daily movements to the ocean throughout the season, including March and April before CO had arrived on the lake. Direct interactions between the two species were limited by this spatial and temporal separation.

Diving durations for CO have been reported in a number of studies and include means of 34 s (Robinson 1923), 39.5 s (McIntyre 1978), 52.1 s (Stewart 1967), 64.4 s (Hatler et al. 1978) and at Drizzle Lake, 30.4 s for inshore dives and 41.1 s for open water. The duration of a dive will reflect the time spent in searching for, pursuing, and manipulating prey (Krebs 1978). Shorter diving times in the littoral regions at Drizzle Lake could result from a high prey density (shorter search time), shallower water (shorter search and pursuit), smaller prey (less manipulation), or a combination of these factors.

The patterns of loon abundance found in this study apply to other lakes on the Queen Charlotte Islands. We have visited about 50 lakes and ponds in this area, and on many of them have seen a similar diurnal movement to the ocean by RT. In three of the largest lakes, there were aggregations of foraging CO in July, and small numbers of non-breeding pairs of RT. Such regular use of lakes by foraging CO may contribute to the morphological divergence of stickleback in this area (Moodie and Reimchen 1976). The reasons for nightly habitation of freshwater by RT and for flocking of CO in the third week of July require further investigation.

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Growth of the Horned Lark at Rankin Inlet, Northwest Territories

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Weight gain, elongation of the seventh primary and the median rectrix, and the schedule of several other aspects of development of a northern race of the Horned Lark (*Eremophila alpestris hoyti*) were studied on arctic tundra at Rankin Inlet, Northwest Territories, Canada. The adult weight of this population was 38.8 g, 15-20% heavier than two temperate races (*E. a. praticola* and *E. a. enthymia*). The nestling growth curve was 29.5 g. The eyes opened between day 2 and 3, the nestling period was 8.9 d. One young barely flew on day 12 and one flew "well" on day 13. The seventh primary was 30.3 mm long and the central rectrix 11.3 mm on day 9. These results, plus the general schedule of plumage and behavioral development, agree with published information on *E. a. praticola, E. a. enthymia*, and *E. a. leucolaema*. It is concluded that *E. a. hoyti* grows more rapidly than more southerly races of the species but the evidence does not show an increased rate of plumage or behavioral development as part of its adaptation to the arctic environment.

Key Words: growth, Horned Lark, *Eremophila alpestris*, arctic tundra, Northwest Territories.

Study of growth rates of the Lapland Longspur (*Calcarius lapponicus*) and the Snow Bunting (*Plectrophenax nivalis*) at Barrow, Alaska (approximately 71°N) showed that these two arctic passerines with markedly different nest-siting strategies grew at very similar rates, and did not appear to grow faster than related species in temperate regions (Maher 1964). Growth of arctic passerines has so far been studied only on fringillids. In 1968 I undertook to study the growth rate of a northern race of the Horned Lark (*Eremophila alpestris hoyti*) to see whether the previous results would be confirmed in a passerine of another family. This species has a continental range in North America with several described races, and some developmental data on other forms are already available. Growth curves have been published of *E. a. praticola* studied in Illinois and at Ithaca, New York (Pickwell 1931) and of *E. a. enthymia* at Matador, Saskatchewan (Maher 1972). Additional development data on *E. a. praticola* in Illinois (Beason and Franks 1973) and on *E. a. leucolaema* in western Wyoming (Verbeek 1967) are also available. The race designations are based on the locality of each study in relation to the race boundaries in the *Check-list of North American birds* (American Ornithologists' Union 1957). Those studies provide a satisfactory basis for comparison with data on *E. a. hoyti*. The latter is 15-20% heavier than *E. a. praticola* and *E. a. enthymia*, presumably as an adaptation to arctic conditions, and its large size may be associated with increased growth and development rates.

Study Area

E. a. hoyti was studied at Rankin Inlet (63°20'N, 90°42'W), located 470 km NNE of Churchill, Manitoba, on the northwest shore of Hudson Bay. Topography within 6.5 km of the settlement is undulating; exposed granite ridges alternate with broad swales containing many ponds and lakes. Maximum elevation is 55-60 m. A lichen-moss - low shrub formation is dominant on ridge tops, uplands, and mesic slopes. Mountain Cranberry (*Vaccinium vitis-idaea*), Crowberry (*Empetrum nigrum*), and Labrador Tea (*Ledum palustre* subsp. *decumbens*) are the dominant vascular plants. Bell Heather (*Cassiope tetragona*) is present in moist depressions and damp crevices in rocks. Slopes and hillsides are occupied by combinations of heaths with *Dryas integrifolia*, *Carex* sp., *Cassiope*, and lichens. Scientific names follow Hultén (1968).

The climate of the area is typically arctic with very short cool summers. Climatic data from Chesterfield Inlet, Northwest Territories, 95 km northeast, show mean temperatures above freezing only in June to September (monthly means 2.9, 8.7, 8.8, and 2.8°C, respectively). Sixty-two percent of the 24.2 cm of total precipitation falls from May to September.

The Horned Lark at Rankin Inlet

Horned Larks at Rankin Inlet were common residents of the drier upland areas of tundra. Almost all nests found were along the edges of roads or trails, screened by grass that was obviously growing on disturbed sites. On 1 July the population of an approximately 12-ha (30-acre) area of very disturbed upland tundra was estimated to be 15-20 pairs. A much larger area of undisturbed tundra had a population of only 5-10 pairs at the same time. Disturbed habitat created by human activities is obviously important to this species in the north.

Mean weight of adult *E. a. hoyti* at Rankin Inlet in May, June, and July was 38.8 g: males 39.9 g (N = 2), females 37.7 g (N = 3). This compares with a May-to-

July mean weight of *E. a. hoyti* specimens in the National Museums of Canada from 11 localities in the Northwest Territories of 40.8 g: males 40.1 (± 2.94 SD, N = 41), females 41.6 (± 2.75, N = 23).

The mean clutch of 10 nests found during incubation was 3.5 eggs, range 3 to 4. Incubation on 12 nests began between 13 June and 5 July, eight of these between 17 and 24 June; egg laying therefore occurred in mid-June. They were single brooded. Comparable clutch-size data are 3.09 eggs for *E. a. enthymia* at Matador, Saskatchewan (range 2 to 5, N = 201), 3.14 for *E. a. leucolaema* in Wyoming (range 2 to 4, N = 14), and 3.5 for *E. a. praticola* in Illinois/Ithaca (range 2 to 5, N = 32). Drury (1961) reported two nests of *E. a. hoyti*, with four and five eggs, on Bylot Island, and two nests with six eggs were found on northern Banks Island (W. J. Maher, unpublished data). On Baffin Island where *E. a. hoyti* overlaps with *E. a. alpestris*, Watson (1957) found three nests with five eggs and Sutton and Parmelee (1955) reported a mean clutch of 4.0 (range 3 to 5, N = 7).

Methods

Most nests were found by flushing the incubating female; a few were found by watching feeding females until they returned to the nest. The unconfined nestlings were individually marked, and were weighed in the field with a triple-beam balance accurate to 0.1 g. The seventh primary (counting from the proximal end of the tract) and median rectrix were measured by ruler to the nearest 0.5 mm from the point of emergence from the skin to the tip. Details of development were noted on each nest visit. The weight curves were analyzed following Ricklefs (1967) and Hussell (1972). The day of hatching is day 0.

Results

Growth Rate

Growth of the young larks was typically rapid. The newly hatched young weighed 2.5 g, but since some were fed before the first weighing the mean weight of day-0 nestlings was 3.1 g (Table 1). They left the nest on day 8 or 9 weighing approximately 25 g, having gained an average of 2.4 g/d for 9 d. Their legs were then well developed and they could hop (Pickwell 1931; Drury 1961) although they could not fly for four to five more days.

The nest period at Rankin Inlet averaged 8.9 d for nine young (range 7.5 to 10.5 d). Nest departure time was based on the assumption that the young left the nest a half day after they were last seen in the nest when the nest was empty on the following day. This agrees with a nest period of 8 to 9 d reported by Drury (1961) for this race, and is close to the nest period at Baffin Island, Matador, Wyoming, and Illinois/Ithaca (Table 2).

TABLE 1—Weight records of the Horned Lark at Rankin Inlet

Age (d)	N	Weight: Mean ± SD (g)	Weight: Range (g)
Hatch*	5	2.5 —	2.0– 3.2
0	24	3.1 ± 0.50	2.0– 4.2
1	23	5.4 ± 0.84	4.1– 6.7
2	24	8.1 ± 1.2	6.3–10.5
3	18	11.7 ± 1.0	9.9–13.8
4	18	15.3 ± 1.3	12.7–18.1
5	12	19.0 ± 1.5	16.9–21.5
6	14	21.8 ± 2.6	17.5–25.1
7	18	24.8 ± 2.9	19.0–27.7
8	9	25.8 ± 3.2	20.7–29.9
9	5	26.5 ± 3.9	22.1–31.3
10	2	28.2	27.7–28.8
12	2	28.0	25.7–30.4
13	1	32.0	— —

*Newly hatched young; these weights are also included in day 0 weight.

Specific growth parameters and mean adult weights of Horned Larks at Rankin Inlet are compared with those from Matador and Illinois/Ithaca (Figure 1, Table 3). The weight data of Beason and Franks (1973) were not suitable for similar comparison, and Verbeek (1967) did not publish weight data. *Eremophila a. hoyti* is 14% heavier than the Matador larks and 20% heavier than the larks studied by Pickwell (1931). The specific growth rate constant (K) which measures growth rate relative to the asymptote is similar for all these populations. The weight data (Figure 1), however, do suggest that the populations grow at different rates, the Rankin Inlet population growing fastest, the Matador population at an intermediate rate, and the Illinois/Ithaca population growing most slowly. This conclusion is borne out by comparison of weight gained at the inflection point of the growth curve (Ka/4) (Hussell 1972); this maximum growth rate is 25% higher in the Rankin Inlet birds than in the next most rapidly growing population, at Matador in 1969 (Table 3). Thus, along with a considerable

TABLE 2—Nest period of the Horned Lark

Locality	Range (d)	Mean (d)	N	Source
Rankin Inlet	7.5–10.5	8.9	9	This study
Baffin Island	8–10	9.2	5	Sutton and Parmelee 1955
Matador	7–13	9.3	38	Maher 1972
Wyoming	9–12	10.2	—	Verbeek 1967
Illinois/Ithaca	9–14	10–11	—	Pickwell 1931

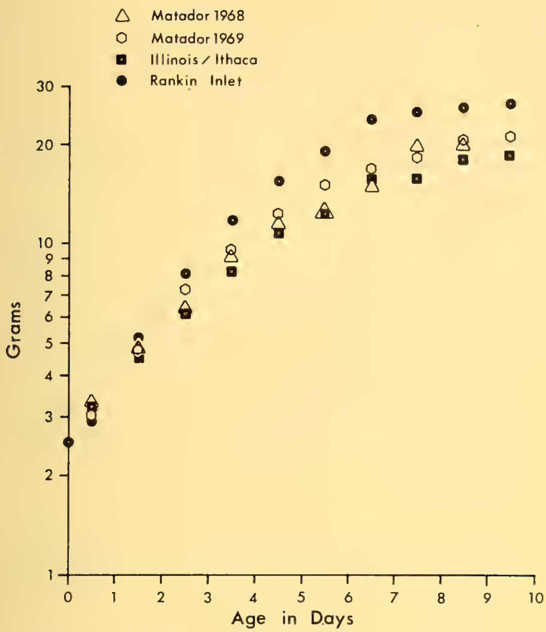

FIGURE 1. Growth curve of *Eremophila alpestris hoyti* at Rankin Inlet compared with growth curve of *E. a. enthymia* at Matador, Saskatchewan and a composite curve of *E. a. praticola* from Illinois and Ithaca.

increase in body size, Hoyt's Horned Lark appears to grow more rapidly than the more southerly forms of the species. Comparison of the age at inflection of the nestling growth curves supports this conclusion (Table 3).

Development of Plumage

At hatching (day 0), Hoyt's Horned Lark nestlings have creamy-yellow down distributed as noted by Verbeek (1967) for *E. a. leucolaema,* except that down was lacking on the crural and abdominal tracts and was present on the frontal tract (cf., Saunders 1956). Presence or absence of down on the ocular tract, the upper tail coverts, and the carpal remex coverts was not recorded. On the capital tract down was 5 mm long, and it was 10 mm long on the mid-dorsal tract, similar to the averages of 5.7 and 8.0 mm, respectively, for the same tracts on the Prairie Horned Lark (Beason and Franks 1973).

Skin color on day 0 was dark bluish-gray dorsally and salmon pink ventrally, and papillae of the remiges were visible in the skin. Feather papillae were generally visible on day 1 and protruded through the skin on most feather tracts on day 2. On late day 2 or day 3 pin feathers began to emerge on the malar tract, but not on other parts of the head (superciliary, auricular, and submalar tracts) nor on the anal circlet. Drury (1961) reported pin feathers evident on day 2 on *E. a. hoyti* on Bylot Island. This schedule of eruption of the pin feathers in *E. a hoyti* agrees with that of *E. a. praticola* (Pickwell 1931; Beason and Franks 1973).

The sheaths began to break on all body tracts on day 4. Sheaths of the primaries and the rectrices began breaking on day 5. By day 6 feathers were emerging from the sheaths on the head, and the young appeared well feathered, although the ventral apterygium was still prominent. Down began to be shed on day 6 and was mostly gone by day 7, although it tended to remain longer dorsally. On day 9 the young were completely feathered except for the posterior abdomen, although tufts of down persisted on the superciliary tract. The shedding of down was as reported by Pickwell (1931) and Beason and Franks (1973) for *E. a. praticola.* By day 12, three days after nest departure, there was no down present, although Beason and Franks (1973) reported down on the superciliary tract of one of two young captured on day 27.

Other observers have generally reported similar timing of these events. Verbeek (1967) noted that the primaries and secondaries of *E. a. leucolaema* broke their sheaths when the young were 6 d old. Pickwell (1931) found for *E. a. praticola* that feathers were unsheathing on back, head, and breast on day 5, and

TABLE 3—Specific growth parameter of Horned Larks

Locality	Mean adult wt. (g)	K[1]	Age inflection of growth curve (d)	Ka/4[2] (g/d)	Asymptote of nestling growth curve (g)	R[3]
Matador 1968	33.35	0.456	4.7	2.4	21.4	0.64
1969		0.500	4.4	2.7	21.4	0.64
Illinois/Ithaca	31.0	0.464	4.4	2.1	18.5	0.60
Rankin Inlet	38.8	0.494	3.9	3.6	29.5	0.76

[1]K = overall growth rate constant (Ricklefs 1967).
[2]Ka/4 = maximum growth rate, at inflection of curve (Hussell 1972).
[3]R = ratio of nestling growth curve asymptote and adult weight (Ricklefs 1967).

that unsheathing became rapid and general, including the primaries, on day 6.

Data on the growth of seventh primaries and central rectrices of *E. a hoyti* at Rankin Inlet (Table 4) show that the most rapid growth rate[1] of these feathers, from approximately day 2 to day 5, coincides with the most rapid rate of weight increase (Figure 1). Similar relationships of the growth of primary feathers and weight gain were observed in the Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) and other species (Willson 1966).

Published data on the growth of the primaries and reactices of *E. a. praticola* (Beason and Franks 1973; Pickwell 1931) are not strictly comparable with the Rankin Inlet data because of slight differences in methods. Beason and Franks (1973) measured the first primary (counting from the inside out), Pickwell (1931) measured the "longest primary" (probably seventh, possibly the eighth or ninth), our data give the length of the seventh primary. The rectrices measured in the same studies were the central rectrices, "total length of tail," and the central rectrices. Nevertheless, the results show similar rates of elongation of flight feathers, although critical comparisons are not possible. Comparison of primary lengths on day 9, the usual day of nest departure, shows lengths of 30.3 mm and 28.8 mm for *E. a. praticola* and 30.3 mm for Hoyt's Horned Lark. The central rectrices have measurements respectively also on day 9 of 10.6, 11.2, and 11.2 mm. These results must be considered tentative because of the ways the data were taken; but they suggest that, despite the different rates of weight gain in these populations and 15–20% differences in adult weight, the plumage tends to develop at very similar rates.

[1]Calculated as relative growth = length increment $\cdot$ d^{-1} $\cdot$ length at start of time interval over which increment was measured $^{-1}$.

Physical Development

Newly hatched young could make grasping motions with their feet when picked up, and had a prominent egg tooth. They gaped at any disturbance. The gape was undirected, and was executed with the body horizontal and the neck raised. On day 1, nestlings used their legs to prop themselves up when gaping, and they could right themselves, although with difficulty. Feces were expelled in a fecal sac (presumably true on day 0 also, but not noted). The eyes of most young were partly open on day 2 and fully open on day 3. After the eyes were open, gaping declined, and 3 d later most sat silently or crouched in the nest when it was approached although gaping was noted occasionally until day 12.

The first vocalizations were faint "seep" or "peep" calls on day 2. No other vocalizations were heard until just prior to nest departure, on day 8 when a loud distress call and a "tsip" or "chip" (a location call?) were uttered.

Physical coordination developed gradually. The young sat on their tarsi by day 6. Some struggled to escape and gave the distress call when picked up on day 8. On the following day, the normal day of nest departure, the young struggled strongly when held, jumped from the hand, gave the distress call, and responded vocally to adult alarm calls. One young which jumped from the nest when approached on day 10 was still defecating in a loose fecal sac. Another chick 180 m from its nest on day 12 could fly approximately 3 m and was essentially fully fledged. It produced normal feces and its egg tooth was still present. Another young flew "well" on day 13, although we could still catch it by running in pursuit.

TABLE 4—Lengths of seventh primary and central rectrix of young Horned Larks at Rankin Inlet

	Primary lengths			Rectrix lengths		
Age (d)	N	Mean ± SD (mm)	Range (mm)	N	Mean ± SD (mm)	Range (mm)
2	21	0.37 ± 0.1	v* 0.5	18	0.10 ± 0.1	v – tr**
3	20	2.0 ± 0.7	0.5 – 3.5	20	0.18 ± 0.2	v – 0.5
4	18	5.8 ± 1.2	3.0 – 8.5	18	0.90 ± 0.4	v – 1.5
5	9	11.4 ± 0.8	10.0 – 13.0	11	2.5 ± 0.8	1.0 – 3.5
6	14	14.9 ± 3.0	7.0 – 18.0	15	4.4 ± 1.2	1.0 – 6
7	14	20.7 ± 4.8	10.5 – 26.0	13	6.6 ± 2.3	1.5 – 9
8	13	26.5 ± 4.7	14.0 – 32.0	13	9.5 ± 2.9	3.4 – 12.5
9	6	30.3 ± 5.4	19.5 – 35.5	6	11.2 ± 2.7	6 – 14
10	2	30.8	28 – 33.5	2	10.5	
12	2	51	49 – 53	2	23	
13	1	58		1	28	

*v = Feather papilla visible in skin.
**tr = Trace, < 0.25 mm.

Discussion

The results show that a northern race of the Horned Lark (*E. a. hoyti*), studied at 63° N, grew more rapidly than races from temperate latitudes. The specific growth rates (K) from Matador, Saskatchewan, Illinois and Ithaca, and from Rankin Inlet are very similar (Table 2). Other growth parameters — e.g., days taken to reach the inflection point of the growth curve, growth rate at the inflection point (Ka/4), and indeed the weight curves themselves (Table 3, Figure 1) — support the conclusion that the Rankin Inlet population grew faster than the other forms.

Previously I concluded (Maher 1972) that the Illinois/Ithaca Horned Larks grew at essentially the same rate as the Saskatchewan birds, but the data as presented here suggest that they grew slightly more slowly. Other studies of geographic variation in species growth rates have given inconsistent results. A difference in growth curve asymptote of 19% and different specific growth rates (K) for the Yellow-headed Blackbird between Washington and Utah led Ricklefs (1968; data *from* Fautin 1941, Willson 1966) to conclude that the two populations grew at different rates. On the other hand, three published growth curves for the Chipping Sparrow (*Spizella passerina*) from New York and Michigan had identical asymptotes, and almost identical specific growth rates (Ricklefs 1968; data *from* Weaver 1937, Walkinshaw 1944, Dawson and Evans 1957).

Growth rates can differ within a single season. For example, the growth rates of early and late broods of the European Robin (*Erithacus rubecula*) at Oxford differed by 9 and 20% in each of two "ideal" seasons (Ricklefs 1968; data *from* Lack and Silva 1949). Seasonal variation in growth rates was not a problem with the Rankin Inlet Horned Larks as they were single brooded with a high degree of breeding synchrony. The Matador samples and Pickwell's (1931) sample were composite ones but it is assumed in this comparison that the samples reasonably approximate the seasonal optimal growth rate.

The observed growth rates may also be affected by nutritional deficiencies (Ricklefs 1968). An insurance against such distortion was to exclude from comparisons the weights and measurements of young birds that had begun to lose weight or show other signs of being poorly nourished. This was done for Rankin Inlet and Matador data. Pickwell (1931) gave no details on this.

Development of plumage, nest departure, and other aspects of avian development are essentially independent of the nutritional state of the young, and are not affected by nutritional deficiencies until starvation becomes pathological (Lack and Silva 1949; Willson 1966; Ricklefs 1968). Thus, information on development rates can be used to complement conclusions derived from comparison of weight curves; but development can also vary independently of weight gain.

The size of samples on which growth curves are based also influences their usefulness for comparison. The 1969 data from Matador are based on 23 to 41 young per day for the first 10 d, but the 1968 Matador sample was reduced to five young on day 5 and three on day 8. The Rankin Inlet sample (Table 1) was intermediate in size while Pickwell's sample was only seven on day 5 and four on day 9.

Not all developmental events were recorded by all authors who studied the Horned Lark, and some events, particularly behavioral ones, might not have been noted when they first appeared. Eye opening, nest departure, and fledging are three critical events which all authors reported. Drury (1961), Verbeek (1967), and Beason and Franks (1973), as well as this study, agree that the eyes open between day 2 and day 3, although Pickwell (1931) reported day 3 or day 4. Nest departure time (Table 2) also showed broad agreement among observers. The two largest samples suggest that *E. a. hoyti* at Rankin Inlet may leave the nest almost half a day earlier than *E. a. enthymia* at Matador. Reported ages at fledging, however, are very similar. At Rankin Inlet, a chick was just able to fly 3 m on day 12, but one flew well on day 13. Drury (1961) also reported that *E. a. hoyti* flew after 4 d out of the nest, and that nest leaving was at age 8–9 d; thus fledging was on day 12 or day 13. Pickwell (1931) reported young flying 30 m (100 ft) on day 14 when it was out of the nest 4 d, and Verbeek (1967) reported nest leaving when young were 9 d old and that they flew 5 d later. He saw one young 15 d old fly 75 m (250 ft). Again there is broad agreement among observers on the timing of a critical event.

Finally, development of plumage and the data on elongation of the seventh primary generally support the conclusion that the development of the young, apart from weight gain, proceeds at approximately the same rate in the arctic and temperate forms.

Hoyt's Horned Lark is heavier than the other races when it leaves the nest, and has gained a higher proportion of adult weight (R, Table 3) than they have. The several other development indices compared here, however, suggest that plumage development and physical development proceed at approximately the same rate as in the temperate races. As part of its arctic breeding strategy, *E. a. hoyti* appears to emphasize rapid weight gain in the nest. Weight gain is energetically most efficient early, because the chicks are inactive and the insulation of the nest and benefit of the huddling brood allows more energy to be invested in weight gain (Royama 1966). Thus, an increased rate of

growth along with an increase in body size are involved in the adaptation of Hoyt's Horned Lark to the arctic environment. These results contradict earlier conclusions (Maher 1964; Ricklefs 1968) that growth rates of arctic passerines are not increased over rates of passerines in the temperate zone.

Acknowledgments

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Spotted Turtles (*Clemmys guttata*) in Eastern Ontario and Adjacent Quebec

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The known range of the Spotted Turtle, *Clemmys guttata*, is extended by new records: Alfred Bog, Prescott County; Mer Bleue, Regional Municipality of Ottawa-Carleton; Stoco Lake, Hastings County; Newington Bay, Stormont County; the Kaladar area of Frontenac County; Algonquin Park, Nipissing District. Observations from Peterborough, Peterborough County, and Lake Scugog, Ontario County, may also have represented this species. A Quebec record from near Sherbrook is the first in this century. In central and eastern Ontario and southern Quebec the occurrence of the Spotted Turtle may be restricted to available bogs where they are relicts of a larger continuous post-glacial range during the warmer hypsithermal period.

Key Words: Spotted Turtle, *Clemmys guttata*, eastern Ontario, western Quebec, relict distribution, bogs, new records.

The Spotted Turtle, *Clemmys guttata*, is usually considered to have a distribution restricted in Canada to southwestern Ontario adjacent to Lake Erie and Lake Huron, with isolated records in southwestern Quebec (map 43 *in* Logier and Toner 1955, 1961; map 98 *in* Bleakney 1958; map 6 *in* Conant 1975). Ernst (1972) indicates a wider range but had only one record (from Quebec) additional to those used by the above authors. Cook (1977) indicated that new records were available from eastern Ontario but these were not documented. The records reported here from eastern and central Ontario may be indicative of a scattered, disjunct distribution, east of the more continuous range of the species in southwestern Ontario (Figure 1). These new records are of particular interest because this species is generally included in lists of rare or endangered forms in Canada, based on a relatively restricted distribution and apparently declining numbers in southwestern Ontario (Cook 1970, 1977).

Observations and Records

Alfred Bog and Mer Bleue

One Spotted Turtle was identified in the Alfred Bog, 8 km SE of Alfred, Prescott County, about 10 July 1974 by LL, A. Forsyth, and P. Ward. On 28 May 1975, the presence of this turtle was verified when a female was photographed by JDL and D. M. Wood (National Museum of Natural Sciences, Herpetology Section, photograph numbers 391-1, -2). A female was noted at the Mer Bleue bog, 14.5 km SE of Ottawa, Regional Municipality of Ottawa-Carleton by LL, Forsyth, and Ward 9 July 1974 and verified on 30 May 1975 when a female was photographed there by Black and R. Chenier (NMNS:HS photos 401-1). Two additional females were subsequently discovered there by JDL and D. J. White 3 June 1975 (NMNS:HS photos 396-1, -2, -3). On 10 June 1975 FRC, JDL, and J. A. Johnston searched Mer Bleue in the areas of the earlier sightings and saw three Spotted Turtles. Two of these were captured, measured, marked, and released at their capture site (NMNS:HS photos 391-1 to -10; 392-1, -2; 397). One was an adult female and the other an adult male. They were marked by the shell notching method of Cagle (1939) with one notch in the first plastral scute and one in the first and second marginal scutes on the left side of the carapace respectively, giving them code numbers 1:1-0 and 1:2-0. Measurements (in millimetres) were as follows: carapace straight line length × width, and plastron length × width, 109.4 × 82.7 and 99.9 × 63.9 for the female; 113.9 × 85.0 and 98.9 × 59.9 for the male. The female showed conspicuous growth rings on the plastral scutes but the outer ones were very difficult to distinguish. Her age was estimated to be between 14 and 17 yr. The male had a very worn shell and no ring count was possible.

The 1975 Alfred Bog individual and the first three 1975 Mer Bleue turtles were found out of water and were moving overland on the bog. These may have been seeking, or returning from, egg-laying sites, as the late May to early June period when they were observed coincided with nest-site search activity in local Snapping Turtles (*Chelydra serpentina*) and Painted Turtles (*Chrysemys picta marginata*) in the

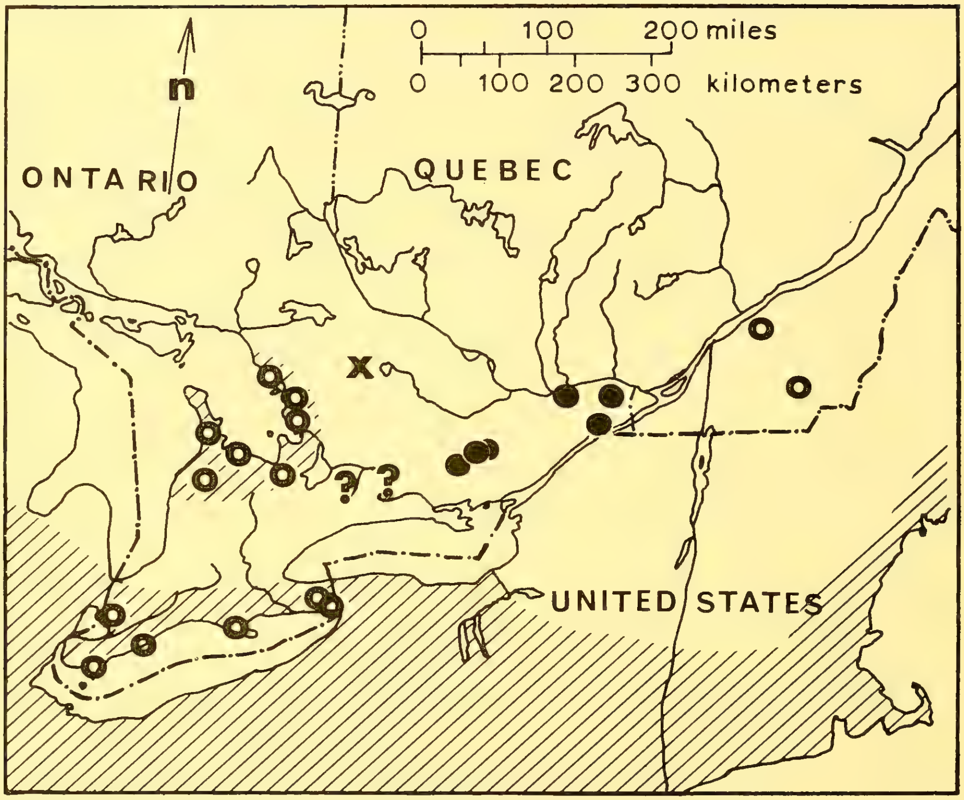

FIGURE 1. Map of Spotted Turtle distribution in Ontario, Quebec, and the adjacent United States. The hatched area is the range as shown by Conant (1975, map 6). Open circles are records plotted by Logier and Toner (1955, 1961), Bleakney (1958), and Ernst (1972) or in NMNS files within the area shown by Conant (1975). Solid circles are new records, verified by the authors, "x" indicates a previously published record by Ontario Ministry of Natural Resources (1975) and "?" indicates unsubstantiated sight records by others which probably were this species. See text for details.

Ottawa area in 1975. It is likely that there is little interspecies difference in egg-laying period at this latitude. The 10 June Mer Bleue turtles were at small ponds in the bog (Figure 2). One was first observed surfacing and probably had been flushed from a basking site on floating vegetation nearby. The next was basking on the bank of a beaver channel and took cover on the bottom where it was conspicuous on the bare mud. The third was basking at a pond edge and took cover within the mud of the pond bottom but was captured by immediately groping for it, by hand.

On 3 August 1979, Erich Haber and A. F. Muhammad, Botany Division, National Museum of Natural Sciences, found two additional Spotted Turtles in Alfred Bog. One of these was a juvenile: carapace 32.3 × 31.9, plastron 26.7 × 17.8. It appeared to have one season's post-hatching growth, so probably was from an egg laid the previous summer. Ernst and Barbour (1972, pp. 74–75) give the average dimensions of newly hatched turtles as carapace 29.8 × 31.3 and plastron 26.4 × 16.0. The other individual was a male: carapace 115.5 × 83.3, plastron 102.2 × 62.1.

Other Eastern and Central Ontario Records

Several other reports from eastern Ontario are available. LL (1975) noted Spotted Turtles at three sphagnum bog localities within the Cataraqui Region during his field work in the Kingston area in 1974–1975 for the Ontario Ministry of Natural Resources. Near Stoco Lake, 6.3 km E of Tweed, Hastings County, a mature male was captured 8 June 1975 by LL, Ian MacDonald, and M. Walsh. This individual measured 146 mm carapace length, and had several scars on the carapace, with the toes of one front foot mangled but healed at the time of capture. It had been basking in a shallow marl pond, which had a depth of approximately 13 cm. A smaller individual

FIGURE 2. A small pond in Mer Bleue where one Spotted Turtle was captured 10 June 1975. FRC is to the left, at 176 cm for size comparison.

had been noted in July 1974. LL and Ann O'Brian saw one individual 11 July 1975, but during 10 additional field trips in this area in the summer of 1975 no other Spotted Turtles were seen. A shell was found by LL at Newington Bog, near Newington, Stormont County, in October 1974.

RVL had reports since 1973 from two local trappers in Frontenac County of a small turtle with which they were unfamiliar, which was described as being slightly smaller than the average Painted Turtle (*Chrysemys picta*) with sparse orange-yellow spots on the back. One of these trappers, Keith Knight, later secured two specimens matching this description near Beaver Creek, Lot 1, Concession X, Kaladar Township, on 17 or 18 April 1974. These individuals were placed in an enclosure in a small creek on the north shore of Bull Lake, Kennebec Township, but subsequently escaped before RVL could confirm the identification. Despite a close watch on the area by Knight no further sightings of this species were made until 5 April 1976 (air temperature 10°C) when Knight picked up one individual on the shore of a small pond 2.4 km S of Lingham Lake, Lot 2, Concession IX, Kennebec Township. On 24 September 1976 a female (115 × 87 mm carapace, 104 × 65 mm plastron) was found at Bull Lake by Knight's 12-yr-old son. It was identified by RVL as a Spotted Turtle and released the same day. Another, or the same, individual was captured 17 April 1977 and later released. Millar Oliver of Kaladar had noticed similar turtles around small ponds 4.8 km W of Kaladar about 1.6–3.2 km N of Ontario Highway 7. One examined by RVL was a female with a carapace 114 × 89 mm and plastron 114 × 54 mm.

Two sightings have been recorded from the southern portion of Algonquin Park in small ponds adjacent to Ontario Highway 60 between Opeongo Lake and Whitefish Lake, mid-June 1967 and 24 May 1970 (Ontario Ministry of Natural Resources 1976; J. A. Simpson and R. D. Strickland, Ontario Ministry of Natural Resources, Whitney, Ontario, personal communication. Duplicate photographs have been deposited with the NMNS:HS).

Two unsubstantiated reports exist for central Ontario. Donald B. Camp (personal communication, 4 April 1965) noted a Spotted Turtle picked up on Highway 7, 4.8 km E of Peterborough, Peterborough County, in the fall of 1964, and John Foster to F. W. Schueler (personal communication FWS to FRC 2

November 1972) reported seeing one at Lake Scugog, Ontario County. At the time FRC assumed both reports were to the more widely distributed Blanding's Turtle (*Emydoidea blandingi*) which, like the Spotted Turtle, has a dark shell and yellow markings, but its markings are more numerous and often streaked. The Spotted Turtle has fewer and round spots (to a total of 114 on the upper shell) (Ernst and Barbour 1972, p. 73). Blanding's Turtle is larger (to 268 mm) (Conant 1975) and its dark unspotted head and yellow throat distinguish it from all other Canadian turtles. In the light of recent records it is likely that the reports in question actually were Spotted Turtles as originally concluded by the observers.

Quebec Records

Disjunct reports from the Eastern Townships of Quebec have been variously treated. Provancher (1874, p. 295) reported it from Nicolet. Logier and Toner (1955, p. 45) also credited Provancher with a record from Quebec City but Bleakney (1958, pp. 14–15) pointed out that this was a mistranslation of the French text which actually stated that the species was rare in Quebec Province, known only from Nicolet, and not to be expected at Quebec City. But Bleakney retained the Quebec City record as a doubtful locality on his map. Logier and Toner (1961) removed it from their second edition. The only new record for Quebec since Provancher's report was mapped but not documented by Ernst (1972) who also showed both Nicolet and Quebec City localities. This recent observation is based on a specimen found crushed on the road, and not preserved, "5 miles [8 km] south of Sherbrooke on Quebec route 5" (C. H. Ernst, personal communication, 13 September 1975).

Habitat and Zoogeographic Considerations

The Spotted Turtle is an inhabitant of "marshy meadows, bogs, swamps, small ponds, ditches and other bodies of water" (Conant 1975, p. 47) and presumably largely avoids rivers and rapidly flowing streams. It was once common in southwestern Ontario in the marshes of Point Pelee and Long Point, the woodland ponds and a stream at Turkey Point and the bogs at Go Home Bay, Georgian Bay (Logier 1939, pp. 49–50). Cook (1970, p. 12) has pointed out that a decline in abundance is indicated for Point Pelee since 1913. Presumably the extensive drainage of marshland in southern Ontario has reduced suitable habitat throughout this portion of its range.

Small deep ponds and lakes present in bogs or with boggy margins may be its main, or only refuge in eastern Ontario. Because of severe winters in this area compared to southwestern Ontario, shallow marshlands and ditches may often freeze too deeply to allow consistently successful hibernation. Field work in the Ottawa region over the past 67 yr by three successive resident herpetologists (C. L. Patch 1913–1950, J. S. Bleakney 1952–1958, and FRC since 1960), their encouragement of others to report unusual specimens, and field excursions by The Ottawa Field-Naturalist's Club since the 1880s has provided no previous records of Spotted Turtles in the area. Although bog habitats are visited regularly by naturalists, Spotted Turtles have a peak of conspicuous activity in the spring (95% of 416 captures in a study area in Pennsylvania were taken between March and June) (Ernst and Barbour 1972), a period when high water makes access to such areas difficult. The recent interest in rare and disjunct bog plants and insects by naturalists and in environmental surveys may have increased the likelihood of early visits to these habitats and consequently heightened the probability of observing this turtle. We suggest that at the northeastern fringe of their range Spotted Turtles survive as small populations restricted to suitable deep ponds and small lakes within bog areas (used here in its widest sense, and thus including fens) and do not attain population densities sufficient for them to expand into less suitable adjacent areas where they would be more frequently observed. Because of the number of observations that have come to light at such sites, and the difficulty of access to many of them, we do not believe these new records are a result of recent introductions. They are likely relict in these localities from the post-Wisconsin glaciation "thermal maximum," or hypsithermal, when warmer temperatures may have made a continuous range over southern Ontario possible. They may have been gradually isolated in their present localities during the last 5000 yr. Other examples of disjunct distributions attributable to range expansion during this period, and subsequent retraction from, or isolation in, intervening areas exist for other reptile and amphibian species in eastern Canada (Bleakney 1958).

Large portions of both the Alfred bog and the Mer Bleue bog are apparently unsuitable habitat for turtles. These areas are forested with Black Spruce (*Picea mariana*) and Tamarack (*Larix laricina*) with most open areas consisting of dry *Sphagnum*, covered with a dense *Kalmia-Ledum-Chamaedaphne* heath. Blueberries (*Vaccinium* spp.) and Cotton-grass (*Eriophorum spissum*) are abundant in these areas.

In both bogs, the turtles were found only in the wettest, most open areas near the center of each bog where a flat, saturated, floating *Sphagnum* mat had developed with open ponds nearby. These areas are largely dominated by sedges including *Carex exilis*, *C. paupercula*, *C. rostrata*, and *C. pauciflora*. The only heath plants in abundance were Bog Rosemary (*Andromeda glaucophylla*) and Leatherleaf (*Cassan-*

dra calyculata). Other common plants were Pitcher-plant (*Sarracenia purpurea*), Sundew (*Drosera rotundifolia*), Virginia Chain Fern (*Woodwardia virginica*), and Scheuchzeria (*Scheuchzeria palustris*). Buckbean (*Menyanthes trifoliata*) and Calla Arum (*Calla palustris*) were common around the margins of the pond.

Exact locations for the Mer Bleue specimens are on file in Herpetology Section, NMNS. Naturalists and others are urged not to remove specimens from the area. Although we do not have any population estimates we suspect that these are relatively small at such sites. Spotted Turtles do not become mature until after their sixth year and lay an average of only 3.58 eggs per clutch in Pennsylvania with hatching success only 58.1% (Ernst and Barbour 1972, p. 73). These data underscore the tenuous position of northern isolated populations such as the ones reported here. We urge that additional sightings at these or new localities be forwarded to the Herpetology Section, National Museum of Natural Sciences, where a file of such observations is maintained, or to any of us personally. Photographs to verify identity of the turtle observed would be appreciated, along with a straight line (from end to end, not along the curve) measurement of the carapace (upper shell), and any distinguishing marks. Shells should never be notched for future identification unless a record of such animals and their marks are sent to the Herpetology Section, because of the possibility of confusion of individuals marked by other observers. Duplication of marks would be particularly unfortunate if detailed life history studies are eventually begun on any of these populations.

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Distribution, Parturition Dates, and Feeding of Bats in South-central British Columbia

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Between 10 June and 4 July 1979 we used mist nets, bat traps, and a hand net to sample populations of bats at 19 sites in the Similkameen and Okanagan valleys of British Columbia. A zero-crossing period meter, broadband microphone, and oscilloscope were used to monitor distribution and feeding behavior of bats by their echo-location calls. A total of 420 bats of 10 species was captured, including *Myotis thysanodes* ((Fringed Bat) and *Antrozous pallidus* (Pallid Bat) previously known from few Canadian specimens. During the study all females we captured were either pregnant or lactating. Feeding behavior of, and habitat use by, some species is described. Over the Okanagan River several species of bats fed in close association with Common Nighthawks (*Chordeiles minor*).

Key Words: bats, *Myotis lucifugus, Myotis yumanensis, Myotis evotis, Myotis thysanodes, Myotis californicus, Myotis leibii, Myotis volans, Eptesicus fuscus, Antrozous pallidus, Plecotus townsendii, Lasiurus cinereus,* parturition dates, feeding behavior, habitat use.

The Osoyoos Arid and adjacent Dry forest biotic areas of the Similkameen and Okanagan valleys in southern British Columbia support the most diverse bat fauna in Canada including 12 species, two of which (*Myotis thysanodes,* the Fringed Bat, and *Antrozous pallidus,* the Pallid Bat) are known in Canada only from this area (Anderson 1946; Cowan and Guiguet 1965). The purpose of this study was to survey a number of sites in these valleys to gather information on the distribution, relative abundance, and biology of bats.

Materials and Methods

Between 10 June and 4 July 1979 we used 9-m mist nets with 381-mm mesh, a hand net, two Tuttle traps (Tuttle 1974) and one collapsible Tuttle trap (Tideman and Woodside 1978) to capture bats. Some individuals were light-tagged (Buchler 1976) and others marked with split celluloid bands (A. C. Hughes, Hampton Hill, England) covered with one of four colors of Scotchlite® reflective tape (red, yellow, white, and blue) to permit recognition of different species in flight.

The echo-location calls of the bats were detected using broadband ultrasonic microphones (QMC K1SM1 or Lincoln; for details see Simmons et al, 1979a) and displayed on a Non Linear Systems Miniscope through a zero-crossing period meter which provided a frequency-time (sonograph) picture of the calls (Simmons et al. 1979a). In some instances bats were recorded on a Lockheed Store 4D tape recorder operated at 76 cm/s, giving a frequency range of the system (microphones, amplifiers, tape recorder) of 5–150 kHz. Using recordings and observations by microphone and period meter of known bats (light-tagged or with reflective bands), we were able to distinguish among several species of bats by their echo-location calls (see also Bell 1979; Fenton and Bell 1979; Fenton and Thomas 1980). We recognized bats attempting to catch insects by the changes in their echo-location calls (Simmons et al. 1979b) and by direct observation.

Results and Discussion

Species Distribution and Relative Abundance

The locations of our study sites are shown in Figure 1, and the relative abundance of different species at these sites are listed in Table 1. Our data indicate that *Myotis volans,* the Long-legged Bat, was relatively common although Cowan and Guiguet (1965) considered it rare. *Myotis leibii,* the Small-footed Bat, appears to be more common and widespread in the area than previously suspected. Lactating and pregnant female *M. leibii* were taken at several sites, indicating the existence of a resident breeding population. Near Okanagan Falls Provincial Park campground, *Myotis californicus,* the California Bat, was commonly caught along the river, while *M. leibii* was captured only on a rocky hillside 300 m away (Table 1). The presence of *M. leibii* in the rocky situation may reflect this species' choice of nursery sites (Tuttle and Heaney 1974).

We captured *M. thysanodes* at three of our study sites (Table 1, Figure 1); it was previously recorded

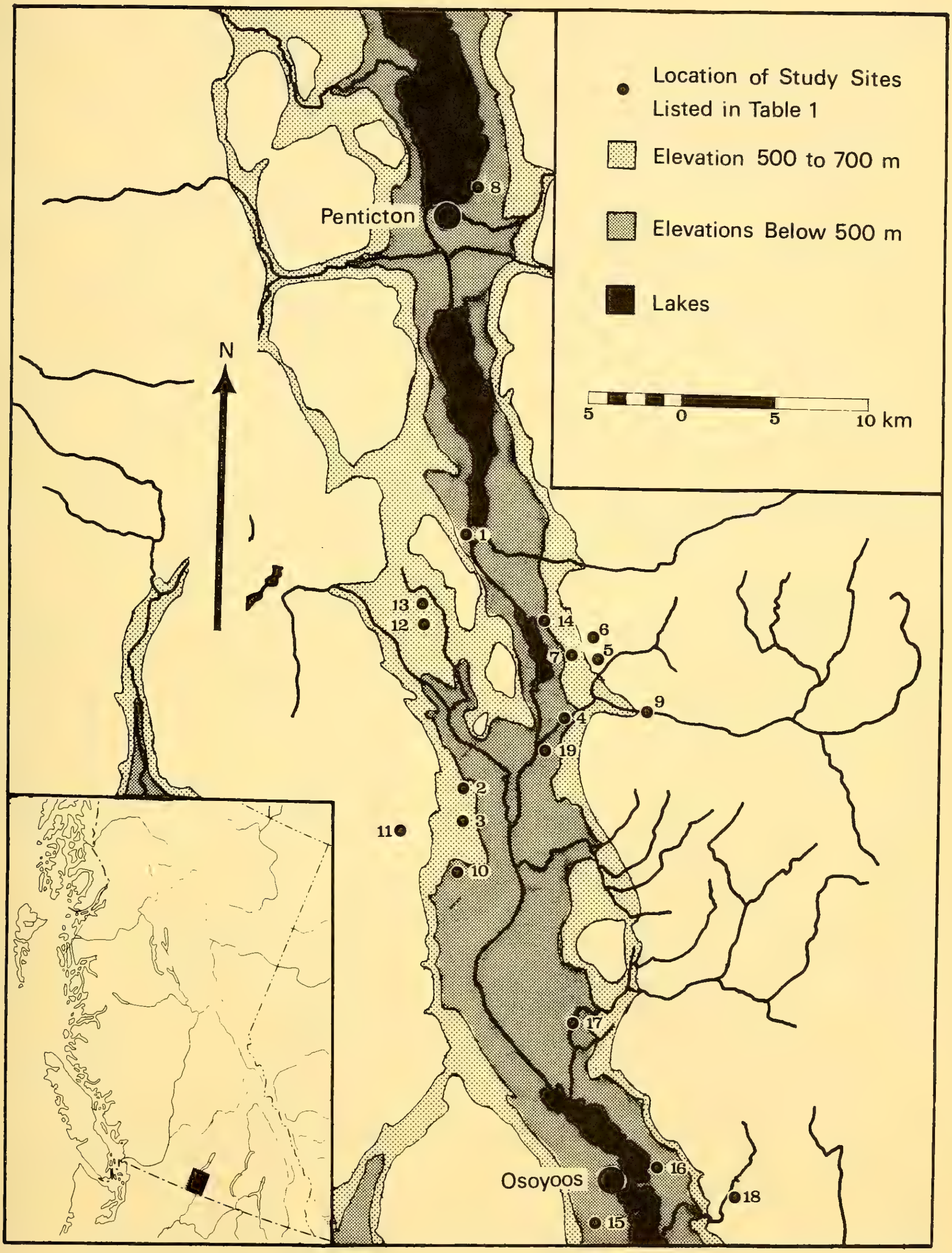

FIGURE 1. The distribution of sites in the study area (inset shows location in British Columbia). The habitat varied from location to location as follows: 1a — over the Okanagan River, running water; 1b — willow (*Salix* spp.) and alder (*Alnus* spp.) along the bank of the river; 1c — talus slope with scrub; 2 — abandoned mine adit in Ponderosa Pine (*Pinus ponderosa*); 3 — pond in Ponderosa Pine forest; 4 — mouth of canyon, fast-flowing creek bordered by alders and Ponderosa Pine; 7 — spring near meadow; 8 — night roost in garage in orchard; 9 — Vaseux canyon, fast-flowing creek lined with willows and alders; 10 — cattle tank in open Ponderosa Pine woodland; 11 — mine shaft in Ponderosa Pine and Douglas Fir (*Pseudotsuga menziesii*); 12 — pond in sage brush bordered by scattered Ponderosa Pine; 13 —cave in cliffs; 14 — talus slope; 15 — abandoned mine adit in open country; 16 — narrow strip of desert near lake; 17 —stony creek with poplar border; 18 — Ponderosa Pine near a small stream; and 19 — floor in mobile home at base of cliff.

TABLE 1—Distribution and relative abundance of bats at study sites (locations in Figure 1)

	Study site																					
	1a	1b	1c	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1a-19
Altitude in m asl[1]	327	327	327	549	518	457	715	760	628	380	760	472	805	672	700	430	430	305	457	762	366	
TN[2]	1	7	4	2	0	1	1	3	1	1	2	0	1	0	1	3	1	2	1	1	0	
NN[3]	4	6	0	0	0	2	0	3	2	0	3	4	0	4	0	0	0	0	0	0	0	
PM[4]	$+_r$	$+_r$	+	–	$+_r$	–	–	$+_r$	+	+	+	·	·	$+_r$	+	+	–			·	–	
Number of bats																						
Myotis lucifugus	21	7	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	8	0	1	0	39
M. yumanensis	11	36	0	1	0	79	0	0	0	0	0	0	0	0	0	0	0	24	0	0	6	157
M. evotis	0	0	2	8	+	5	0	1	1	0	0	+	0	0	0	0	0	5	0	1	0	23
M. thysanodes	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	6
M. leibii	0	0	18	2	0	15	0	0	0	0	0	0	0	1	0	9	1	7	0	0	0	53
M. californicus	0	9	1	4	+	36	+	0	0	0	0	0	0	0	0	2	4	3	7	0	0	66
M. volans	0	+	0	6	+	35	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0	50
Eptesicus fuscus	0	18[5]	+	0	+	5	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	23
Antrozous pallidus	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Plecotus townsendii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Lasiurus cinereus	0	+	+	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	32	70	21	25	0	179	0	1	1	0	0	0	0	1	0	12	5	56	8	3	6	420

[1]Determined from 1:50000 topographical maps.
[2]Number of trap nights.
[3]Number of net nights.
[4]+ indicates a site where the period meter was used, and $+_r$ at site where recordings were made; under species + indicates presence of species determined by echo-location calls via the period meter.
[5]Includes bats taken at a night roost.

from one locality near Vernon (Maslin 1938). As some of the individuals we captured were pregnant or lactating females, and the Maslin (1938) record was of a nursery colony, there is obviously a breeding population in the area.

There appears to be a small resident population of *A. pallidus* in the southern Okanagan valley. We caught two adult males on the night of 14–15 June (Table 1). Only two Canadian specimens are known, an adult male in the Cowan Vertebrate Museum, University of British Columbia, taken near Oliver on 17 July 1931, and an adult female collected at Okanagan Falls on 12 June 1974, now in the collection of the National Museum of Natural Sciences (NMC 42854).

Male *Myotis yumanensis*, the Yuma Bat, *M. californicus*, and *Eptesicus fuscus*, the Big Brown Bat, were more common than females at the higher elevation site 4, where they constituted 68, 60, and 100%, respectively, of the species sample. At a lower elevation site (1) males of these species constituted 0, 30, and 0%, respectively, of the samples. A preponderance of female *M. volans* occurred at site 4 (92%), while nearly equal numbers of male and female *M. leibii* were taken at various locations.

The association between captures per trap-net night and elevations below and above 500 m was significant (chi-square test $P < 0.02$), suggesting greater overall abundance at study sites below 500 m.

Dates of Parturition

The females we captured were all either pregnant or lactating and we caught enough females of four species to provide some indication of the dates of parturition. On 10 and 13 June approximately half of the female *Myotis lucifugus*, the Little Brown Bat, from site 1 were lactating (7 of 17 and 2 of 4, respectively), while at the same site on the same dates, 4 of 11 and 22 of 55 *M. yumanensis* were lactating. Two of seven *M. leibii* taken on 13 June, none of seven on 21 June, and two on 23 June were lactating, whereas two taken on 21 and 23 June were pregnant. All eight *E. fuscus* taken from a night roost on 21 June were pregnant, but at the same roost on 27 June two of eight were lactating and the remainder were still pregnant. These data imply parturition dates for *M. lucifugus* that are similar to those recorded from Ontario (Fenton 1970) and slightly earlier than those reported from Alberta (Schowalter et al. 1979). Our data on the dates of parturition for *E. fuscus* are similar to those from Alberta (Schowalter and Gunson 1979), but our dates for *M. yumanensis* are later than those reported from more southerly locations (Barbour and Davis 1969).

Feeding

We found that bats emerged and began to feed between 21:30 and 21:40. The first to appear along the Okanagan River near Okanagan Falls (site 1) were *E. fuscus* that fed high above the trees in company with large numbers of Common Nighthawks (*Chordeiles minor*). By 21:50 both bats and nighthawks moved closer to the ground, with the *E. fuscus* feeding around the canopy, and the nighthawks over the river. We saw no evidence of agonistic interactions between these bats and the birds (cf., Shields and Bildstein 1979). By this time *M. lucifugus, M. yumanensis*, and *M. californicus* had emerged and were feeding along the river within 1 m of the water (mainly *M. lucifugus*), and along the banks (mainly *M. yumanensis* and *M. californicus*). Both the bats and the nighthawks foraged at close quarters close to the water surface. At higher elevations (e.g., sites 2 and 3) *E. fuscus* also emerged early and fed relatively high, but at these locations we did not observe the feeding congregations of nighthawks and bats, as both were more evenly dispersed in the habitat and foraging above the trees.

Myotis californicus emerged around 21:45 at site 1 and usually hunted along the bank about 5 m from the river's edge, chasing insects from within 1 m of ground level to the top of the canopy, and frequently hunting in the canopy as well. Some marked with reflective bands were observed to hunt over water and close to its surface. Their echo-location calls and feeding behavior, notably their repeated attempts to capture prey over short distances, agreed with the observations of Fenton and Bell (1979).

Myotis lucifugus and *M. yumanensis* fed along the Okanagan River and over adjacent banks at site 1. Over water both species foraged within 1 m of the surface and both made several attempts to capture prey over short distances. When feeding along the banks or the edge of the canopy both species hunted from about 1 m above the ground to canopy height, and both hunted under the canopy on windy nights. On 21 June from 21:45 to 22:45 we surveyed the river and bank area for bats with reflective tags. Over fast-flowing parts of the river *M. lucifugus* with reflective bands outnumbered banded *M. yumanensis* 12:1, while along the bank and near the canopy, the reverse was true, agreeing with capture data on distribution (Table 1). *Myotis lucifugus* with reflective tags were often observed to capture insects from the surface of the water. Farther downstream where the current was slower, equal numbers of light-tagged *M. lucifugus, M. yumanensis*, and *M. californicus* were observed feeding over the water.

At site 1, *M. volans* fed relatively high (to about 10 m over the canopy) along the river bank and over the canopy but not over the river itself. At site 10 *Myotis evotis*, the Long-eared Bat, emerged between 21:35 and 21:45, and flew down a small draw into the Okanagan valley. It was the only species observed at

this location and in flight was very manoeuverable, appearing to either glean insects from foliage or to catch them very close to the foliage.

Myotis leibii emerged around 21:35 and fed along cliffs and rocky slopes at site 1, often concentrating its activity around vegetation or along the edges of rock faces, but apparently always pursuing flying insects. At site 12 (Figure 1) this species fed along the margin of some trees and over a small pond. In this wooded area the bats foraged from about 1 m above the ground to treetop height, while over the water they fed within 1 m of the surface.

Although we did not capture any *Lasiurus cinereus*, Hoary Bats, during our survey, they were easily recognized by their distinctive echo-location calls. This species usually emerged and began feeding around 22:00, and concentrated its foraging activity well above the trees in a variety of habitats (Table 1). They appeared to have been relatively common from lower to higher elevations, based on activity data gathered with the period meter.

Our observations indicate that there is a diverse community of bats with some high population densities in the Similkameen and Okanagan valleys of southern British Columbia clearly worthy of further field studies.

Acknowledgments

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Late Winter Distribution of Black Guillemots in Northern Baffin Bay and the Canadian High Arctic

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In northwest Baffin Bay and adjacent areas of the Canadian high Arctic during March–April 1977–1979, Black Guillemots were concentrated along the edges of landfast ice (mean March 1978–1979 density 1.07 birds/linear km), less concentrated in offshore pack ice (mean March–April 1978 density 0.17/km^2), and rare in polynias. We estimated from aerial surveys that 5000 to 10 000 guillemots overwintered in these areas. No other seabirds were seen.

Key Words: Black Guillemot, *Cepphus grylle*, winter distribution, high Arctic, Baffin Bay, population density, aerial surveys, marine birds.

The Black Guillemot (*Cepphus grylle*) overwinters in many low arctic regions (Bailey 1948; Salomonsen 1950; Dement'ev et al. 1951). In the eastern and central Canadian Arctic there are many winter records from Foxe Basin to the pack ice of southern Davis Strait (Soper 1928, 1946; Sutton 1932; Hørring 1937); these areas are all south of 66° N. In the Canadian arctic islands north of 70° N, however, there are only occasional winter (November– April) observations. Ross (1826) recorded Black Guillemots at Port Bowen, Baffin Island (73° N) during the winter of 1824–25. Some other winter records for areas between 70° and 75° N were given by Hørring (1937), and Shortt and Peters (1942). Farther north, Sverdrup (1904) recorded "myriads of sea-birds, mostly black guillemots" in Hell Gate and Cardigan Strait (76° 30′N, Figure 1) during March 1900; and MacMillan (1927) saw 10 guillemots in Smith Sound on 14 February 1914. In northwest Greenland, Hayes (1867, p. 249), who spent the winter of 1860–61 near Etah (78° 20′N), recorded guillemots during February: "I was much surprised to find them denizens of the Arctic night so near the Pole." Greely (1886) provided February and March records for Polaris Bay, North Greenland (81° 30′N). In the Palaearctic, guillemots occasionally winter north to about 80° N (Nansen 1898; Løvenskiold 1964).

In March–April 1977–1979, aerial surveys were undertaken to assess the importance of open-water areas in northernmost Baffin Bay and adjacent areas to wintering marine mammals. All birds seen during these surveys were also recorded. These data on birds sighted at sea provide the only quantitative information to date on the winter status and distribution of Black Guillemots in the high Arctic, and are the subject of this paper.

Methods

Aerial surveys were conducted in a deHavilland Twin Otter aircraft on 19 April 1977; 15–17 March and 18–20 April 1978; and 17 March 1979. Most surveys were flown at 100–200 m, and at an air speed of 200–220 km/h. Two observers were present on each flight and tape recorders were used. Narrow leads were surveyed with the open water and both observers on one side of the aircraft (one in the co-pilot's seat, one in a right rear seat); each total given in the Results is the larger of the numbers seen by the two observers (usually the front observer), and densities are those figures converted to numbers per linear kilometre surveyed. Along wide leads, the aircraft was flown 500 m off the ice edge with one observer on each side of the aircraft, and figures are the sum of counts by both observers. Over pack ice, surveys were flown with one observer on each side of the aircraft; all birds within 500 m of the aircraft were recorded and resulting densities are numbers per square kilometre. Geographic positions were determined by means of a Global Navigation System (GNS-500) and later reference to NOAA and LANDSAT satellite imagery. Densities from transects were compared by the Mann-Whitney U test.

All guillemots seen in March and most in April were in winter (white) plumage, and were conspicuous against the inky-black water of cracks and leads where they were usually seen swimming or flushing. Most guillemots more than 500 m from the aircraft (and some at lesser distances), however, were probably not detected. Also, some guillemots dove as the aircraft approached and hence an unknown (but probably small) proportion of those present was undetected.

In the central high Arctic, we surveyed 11 small polynias and the large polynia in Hell Gate and Cardi-

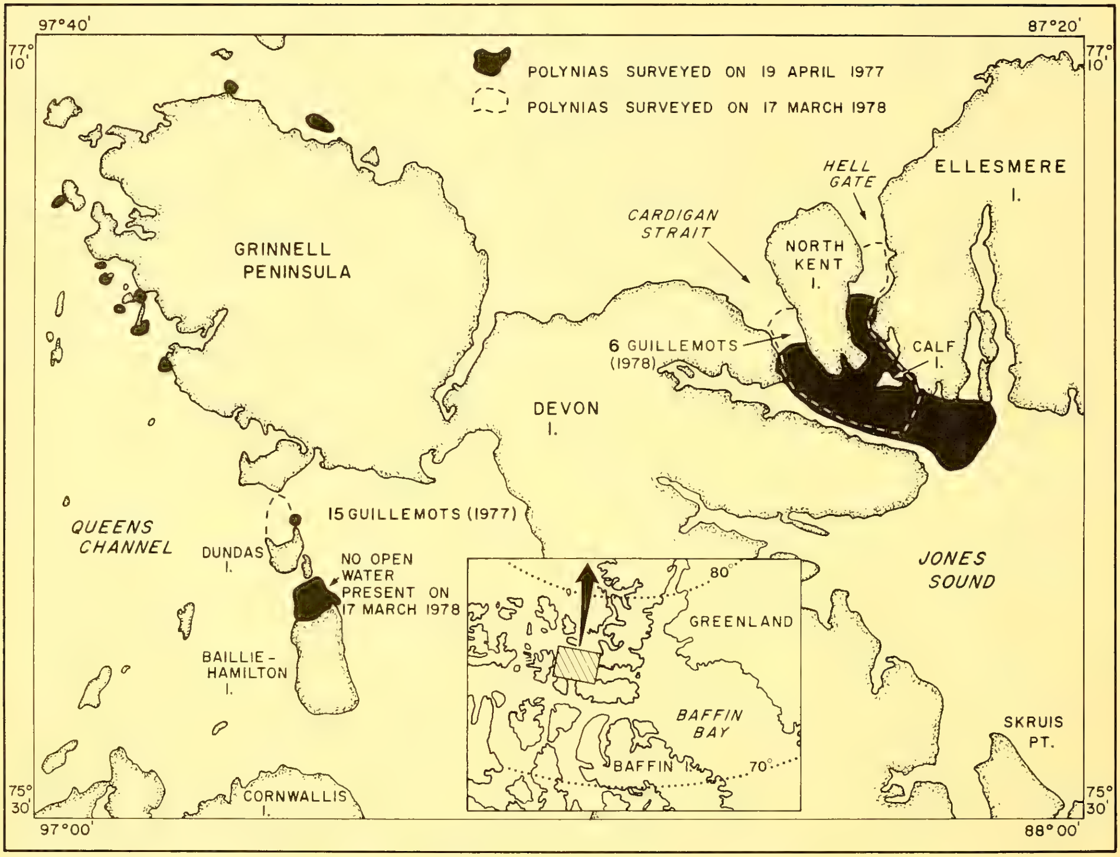

FIGURE 1. Polynias surveyed in the central Canadian high Arctic and numbers of guillemots seen.

gan Strait on 19 April 1977; one small polynia near Dundas Island and the Hell Gate – Cardigan Strait polynia were again surveyed on 17 March 1978 (Figure 1). In northwest Baffin Bay and adjacent areas, extensive surveys were undertaken on 15–16 March 1978 (1448 km surveyed), 18–20 April 1978 (1506 km), and 17 March 1979 (1158 km) (Figure 2). Surveys of northwest Baffin Bay and the Hell Gate and Cardigan Strait polynia followed the edge of the landfast ice; smaller polynias were surveyed completely in one or more passes of the aircraft.

Ice Conditions

During winter and early spring, pack ice almost completely covers northwest Baffin Bay, Lady Ann Strait, southern Smith Sound, and usually Lancaster Sound. With the exception of a few polynias, the waters among the arctic islands are solidly frozen north of Smith Sound and west of eastern Jones Sound, and usually also from eastern Barrow Strait westward (cf., Canadian Hydrographic Service 1970; Aber and Vowinckel 1972; Lindsay 1975). Polynias, the largest of which is located at Hell Gate and Cardigan Strait, occur around western and northwest Devon Island (Lindsay 1975; NOAA and LANDSAT imagery). .

In 1978 and 1979, Lancaster Sound was solidly frozen during the winter and an ice edge persisted across the eastern entrance until mid-summer. Cracks and leads occurred intermittently along all ice edges surveyed (Figure 2,) but were most extensive (up to several kilometres wide) in Glacier Strait, eastern Jones Sound, and (in April 1978) eastern Lancaster Sound. Extensive thin ice was present throughout Lady Ann Strait and more locally off southeast Devon Island. During all surveys, pack ice covered more than 99% of Baffin Bay but new cracks and leads were continually being formed among the shifting pans. Ice edges were well-defined except off northwest Greenland; hence most surveys of the latter area were

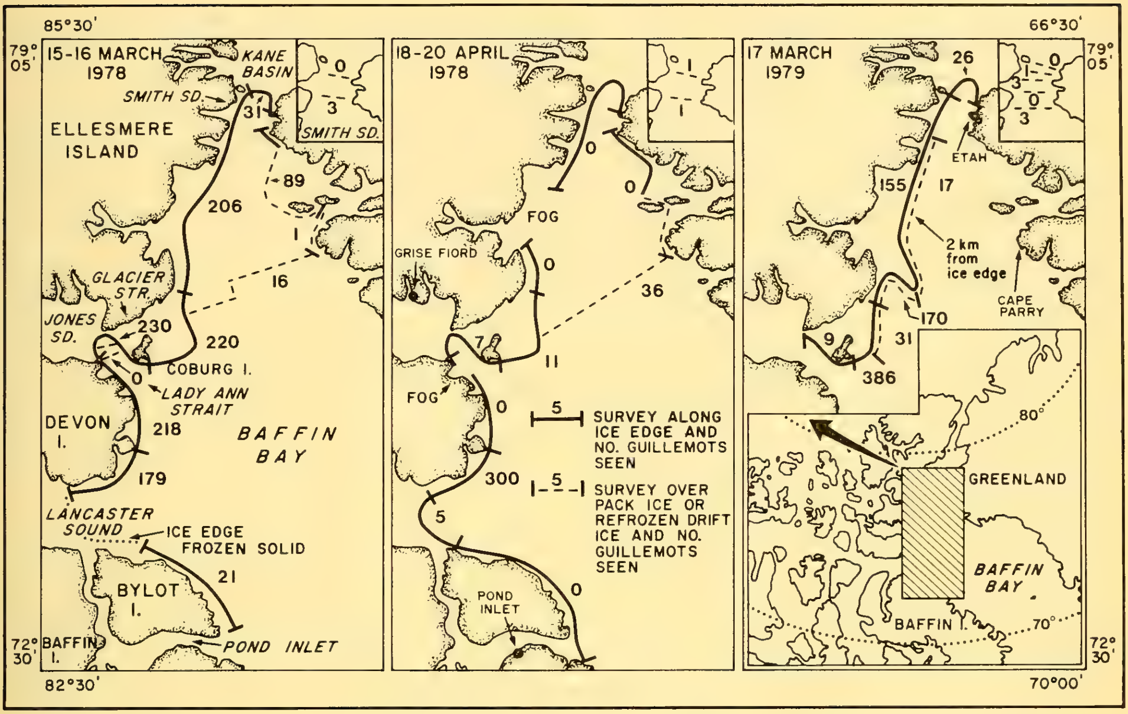

FIGURE 2. Survey routes in northwest Baffin Bay and numbers of guillemots seen.

over pack ice containing many cracks and leads.

The polynias surveyed during 1977 and 1978 were also heavily covered by drift ice, and open water was confined to small cracks and holes. It is probable that many of these polynias are intermittent and completely freeze over during some winters, and for short periods during other winters.

Results

Black Guillemots were seen in only two polynias in 1977 and 1978: 15 were seen north of Dundas Island on 19 April 1977, and 6 were observed in Hell Gate and Cardigan Strait on 17 March 1978 (Figure 1).

A total of 2376 guillemots was seen during three surveys of the northwest Baffin Bay area in 1978 and 1979 (Figure 2). Concentrations were greatest in leads along, or near, landfast ice edges. Mean densities of guillemots along the ice edges surveyed in March 1978 (1.2 birds/km) and March 1979 (0.9 birds/km) were similar ($P > 0.1$). The largest concentrations seen during March were along ice edges off eastern Devon Island (1978; not surveyed in 1979); in eastern Jones Sound and southwestern Glacier Strait (1978; only partially surveyed in 1979); and in southeastern and eastern Glacier Strait (1978 and especially 1979). In 1978, densities along ice edges declined significantly between March (1.2/km) and April (0.3/km) ($P < 0.02$).

Densities offshore in northern Baffin Bay were similar during March and April of 1978 (0.25/km^2 vs. 0.09/km^2; $P = 0.5$); densities offshore in March 1978 and March 1979 (0.25 and 0.41/km^2) were also similar ($P = 0.6$). The overall mean density of guillemots on transects over pack ice in March and April 1978 (0.17/km^2) suggests that about 3900 guillemots were present in about 23 000 km^2 of pack ice habitat available between the transect line from Cape Parry to Glacier Strait and the ice edge across northern Smith Sound. To the south of this area, the offshore pack ice contains fewer areas with open water (NOAA and LANDSAT imagery), and thus likely supports lower densities of guillemots.

Few guillemots were recorded along the ice edge off northeast Bylot Island in March 1978 (Figure 2); there was little open water in this area, and heavy pack ice was present up to the edge of the landfast ice. No guillemots were seen during a reconnaissance survey of the ice edge off northeast Baffin Island from 71°40'N to 70°30'N (not on maps) during March 1979. It is likely that in these areas an open lead between the pack ice and landfast ice occurs only intermittently, and hence they provide poor wintering

habitat for seabirds. Pond Inlet, Eclipse Sound, and Navy Board Inlet are covered by landfast ice in winter and undoubtedly support few (if any) guillemots.

The only other birds noted during our surveys were Common Ravens (*Corvus corax*). One was seen along the ice edge off southeast Ellesmere Island at 77° 30′N on 16 March 1978. One raven remained at Grise Fiord through the winter of 1977–78 (Larry Audlalik, personal communication) and several were seen at Pond Inlet in December 1978 (Finley 1979) and March 1978 and 1979 (this study).

Discussion

Although there are few specific records to indicate that guillemots remain in the high Arctic throughout the polar night, our results strongly suggest that some of these birds regularly overwinter in the area.

The surveys described here included (or sampled) most of the wintering habitat potentially available to guillemots in the Canadian eastern high Arctic and northwest Baffin Bay. The small areas and probable intermittent nature of polynias in the central arctic islands probably preclude their regular use by large numbers of Black Guillemots during winter. In 1978 and 1979, no open water was available west of eastern Lancaster and Jones sounds with the exception of polynias. Guillemots breeding in the central arctic islands, including the considerable populations in Hell Gate and Cardigan Strait and at Prince Leopold and Somerset islands, virtually abandon the area in winter, probably for more favorable areas in Foxe Basin, northwest Baffin Bay, or Davis Strait and beyond. The entire winter population of the Canadian high Arctic and northwest Greenland (including northwest Baffin Bay) may number between 5000 and 10 000 birds.

No overall estimate of the numbers of Black Guillemots nesting in northwest Baffin Bay and adjacent areas is available. About 34 000 birds nest in three large concentrations in western Jones Sound (Calf Island, North Kent Island, and Skruis Point) (Nettleship 1974; Brown et al. 1975), and at least 7400 birds nest in two large concentrations along northeast Somerset Island (Alliston et al., LGL Limited, unpublished data) and Prince Leopold Island (Nettleship and Gaston 1978). Smaller numbers nest along rocky coastlines throughout the central and eastern high Arctic (Brown et al. 1975; Alliston et al., LGL Limited, unpublished data; Johnson et al., LGL Limited, unpublished data). No estimates of Black Guillemot populations are available for northwest Greenland, although Salomonsen (1950) described the species as "abundant." It seems probable that 50 000 to 100 000 Black Guillemots breed or spend the summer as non-breeders in the central and eastern Canadian high Arctic and northwest Greenland, and we conclude that only a small proportion of the summer population overwinters in the high Arctic.

The availability of open water does, and darkness may, affect the ability of the guillemots to overwinter in the high Arctic. Our surveys indicate that in March the highest densities of guillemots were recorded adjacent to landfast ice edges where open water is most consistently available. Ocean currents, local wind conditions, and perhaps upwelling combine to keep such areas free of ice (Dunbar et al. 1967). Lower densities in the offshore pack ice may be due to the random distribution of cracks and leads and to the intermittent presence of open water; should one area freeze over, guillemots may have to fly long distances in search of other open water. At 80° N, the sun is continuously below the horizon for 121 d; how and upon what guillemots feed during moonless periods of the polar night is unknown.

Salomonsen (1950) noted that small numbers of Common Eiders (*Somateria mollissima*) regularly winter in northwest Greenland. We did not record this species during our surveys in 1978 and 1979. Evidently, most seabirds (other than some guillemots) and waterfowl are better able, or only able, to survive at more southerly locations, even though small areas of open water persist through the long winter in the high Arctic.

Acknowledgments

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Reproductive Behavior of the Greater Redhorse, *Moxostoma valenciennesi*, in the Thousand Islands Region

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Reproductive behavior of the Greater Redhorse, *Moxostoma valenciennesi* (Teleostei, Catostomidae), was observed in the Thousand Islands region, upper St. Lawrence River during three spawning seasons. Spawning occurred in a 2-wk period from late June to early July, with water temperatures 16–19° C. Males congregated in shallow runs of sand, gravel, and small rubble substrate, where they generally moved about slowly and frequently nudged and gently pushed one another. Females entered spawning areas generally only when apparently ready to spawn and did not initiate agonistic behavior. Females selected spawning sites, usually gravel. Typical spawning acts involved one female flanked on each side by a male; other males often attempted to join the trio. No nest construction or parental care occurred. American Eels (*Anguilla rostrata*), Fallfish (*Semotilus corporalis*), and Yellow Perch (*Perca flavescens*) preyed on redhorse eggs.

Key Words: Teleostei, Catostomidae, *Moxostoma*, redhorse sucker, reproductive behavior, St. Lawrence River.

The Greater Redhorse, *Moxostoma valenciennesi* Jordan (Teleostei, Catostomidae), is widely distributed in rivers and lakes of the Great Lakes – St. Lawrence River basin except Lake Superior and is known from the northern portion of the lower Ohio River, the upper Mississippi River, and of the Red River of the North basins. Its only known capture in Lake of the Woods, the most northern record of the species, was in 1894 (Jenkins 1970). Scott and Crossman (1973) suggested it probably spawned in May to early July in moderately rapid streams of Canada, but these authors stated "... less is known of the biology of this species than any of the redhorses other than the copper redhorse." Lack of observations of the Greater Redhorse relates to the typical inhabitation by adults of only large and often deep bodies of water, and to its possible rarity and/or disjunctive distribution within the general range. The objectives of this study were to observe and record previously unknown reproductive behavior of the Greater Redhorse.

Study Location and Habitat

The late Grace Meikle invited us to study *M. valenciennsi* at her island, Fishdam Island, on which she resided during each ice-free period of the past 45 yr (until 1972) and at which "redfin suckers" or mullets spawned during each of those years. Fishdam Island (44° 21′50″N, 75° 59′40″W) is in the Thousand Islands region of upper St. Lawrence River (see United States Army Corps of Engineers, St. Lawrence River Chart 115, scale 1:15 000). The closest village, 1.2 km to the west, is Ivy Lea, Leeds County, Ontario. Fishdam Island lies 0.9 km upstream from the north end of the Canadian span of the Thousand Islands Bridge, and 70 m across Out O' Sight Channel from the mainland. It is part of a small group of islands called the Niddery Islands, although some local residents often restrict the name Niddery to Fishdam Island. G. Meikle thought the name Fishdam referred to large numbers of suckers spawning in shallows and effecting a "fishdam," and that Niddery was an Indian word for fish nest, implying a long history of use by the suckers.

Fishdam Island originally was two parallel chains of vegetated small islands and boulder piles, each chain some 180 m in length. Rock fill, a stone wall, and plank bridges now interconnect the parts of each chain. The two chains are spanned by a house and boathouse, under which there is riverflow (Figure 1). Moderate to swift currents flow along the outer edges of the upper and lower points of the upstream portion of the island. Here the substrate at 0.5- to 1.5-m depths is mostly angulate rubble and large gravel. The cove-like area between the upstream points and upstream from the house has gentle current and heavily vegetated deeper water, to 3–4 m.

The main current passes through the boathouse, forming a run of 1.8 m in width and 5.5 m in length. The current is moderate, depth is 0.6 m, and substrate is almost entirely large angulate gravel. The intra-island run further extends 12 m downstream from the boathouse, the main current remaining along the north inner shore. The south edge of the run is bordered partly by a dock, and the section of the run below the boathouse is referred to herein as the dock run. Current in the dock run slackens from moderate to slow, and depth ranges from 0.6 m at the head to 1.8 m at the tail. Substrate in the upper section of the dock run is almost entirely sand, with a few small patches of angulate gravel. The lower section is largely silted. The remaining water area below the house is a heavily vegetated cove 2–3 m maximum depth.

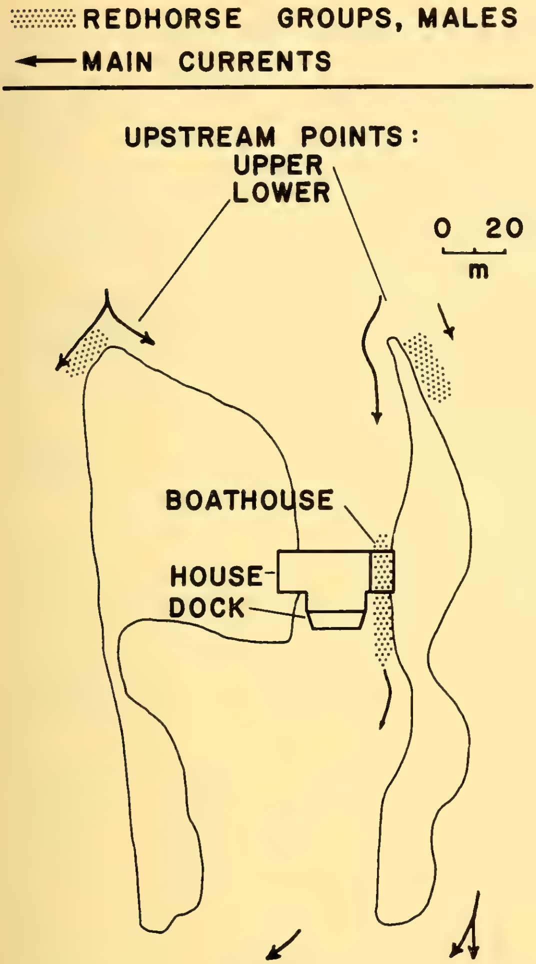

FIGURE 1. Location of Greater Redhorse spawning sites at Fishdam Island. The house, boathouse, and dock spanning the two sections of the island are drawn slightly larger than the scale.

Adult male *M. valenciennesi* congregated in the runs along the outer edges of the upstream points of the island. Spawning occurred by the upper point, and probably the lower, but few observations were made at either point. Redhorses were often seen just above the house, where the current increased in speed en route to the boathouse, but they were generally swimming well above the bottom, and no spawning was witnessed there. Redhorses generally congregated and often spawned in the intra-island run. There was no evidence of spawning in the deeper, silty and relatively sluggish current of the coves.

M. J. Bresnahan, a local resident, informed us that "redfin mullet" (probably *M. valenciennesi*) gather to spawn at numerous other sites of shallow, swift water over gravel and small rubble in the general area of our observations. Particular localities mentioned were Bensons Rift (between Hill and Rabbit islands), Bannisters Island (Island 91), and Anchor Island (Island 92). He also said they spawn near the town of Gananoque, 14 km upstream from the Nidderies.

Methods

Our observations were made under usually excellent conditions for some 30 h during the 1967, 1968, and 1970 redhorse spawning runs, mostly near the end of each run. During some additional 40 h preceding or following redhorse runs, other fishes were observed at the island. The island was also checked for redhorse activity in 1974 and 1975, when it was under new ownership.

The large size of, and our close proximity (1–7 m) to, *M. valenciennesi* usually permitted their study with unaided eyes. Polarizing sunglasses were used when needed to reduce glare, and 7 × 50 binoculars enhanced observation of specimens 7–12 m distant. The elevated dock along part of the intra-island run facilitated observations, and most were made there. Night observations were made with flashlights. Spawning acts were timed with a stopwatch to the nearest 0.25 s.

The water in 1967, 1968, and 1970 was very slightly turbid; vertical visibility was about 3 m and details of fishes and substrate in the runs were readily observable. Turbidity was slightly greater during the high water of 1974. In 1975 the water appeared clear, but had a slight green cast and visibility was about 1.5 m.

Sex of specimens in water was usually discernible. Males have larger breeding tubercles on the anal and caudal fins, and tend to have a longer anal fin and smaller genital papilla than females. Tuberculation and anal fin length were assessed relative to size of specimens, as medium to large females have readily discernible anal and lower caudal lobe tubercles, and small males have a proportionately shorter anal fin than large males and females.

Results

Color, Size, and Numbers of Adults

Adults of *M. valenciennesi* are readily identifiable in clear shallows. They are large suckers with large scales, stout body, large head with inconspicuous breeding tubercles, dark back, coppery to yellowish sides, base of each dorsal and lateral scale with a dark crescent, median fins nearly entirely red or only red-margined, paired fins with conspicuous yellowish free margin in some specimens, reddish orange in others. A moderate amount of individual variation in color was obvious. The dorsum of some specimens was tannish olive; others had a grayish cast. Smaller spec-

imens tended to have red more widely distributed in median fins; a few of the larger specimens had little or no red apparent. Color of nuptial adults did not differ from that of non-breeding adults; sexual dichromatism was absent.

Specimens observed during the spawning runs ranged 1.8–4.0 kg in weight, based on study of the following judged in the river before capture to be about average in size: four males and one female ranging 3.0–3.2 kg and 53–56 cm standard length, 64–66 cm total length. Residents reported maximum weights of 5.4 kg, near the maximum size of the species as summarized by Scott and Crossman (1973). Females seemed to average slightly longer than males, but equality in length of the sexes was common.

The largest numbers of redhorses, mostly males, counted several times in the intra-island run were about 35. Assumedly most females held in the deeper, slower water above and below the intra-island run; most females that spawned in the dock run entered the run from downstream briefly prior to spawning. G. Meikle reported that during the peak of past runs up to 60 redhorses occurred in the dock run and slightly below, and that many more occurred along the upstream points. Ten to 20 redhorses were frequently seen along the upper point, and 10–20 off the lower point, but numbers there were probably higher because redhorses often extended at least to observational limits.

Spawning Periods and Temperatures

In 1967 the spawning run began on 27 June. On 5–6 July spawning was frequent in the dock run. On 7 July only five redhorses were in the dock run during the morning, and only one spawning act was seen; no redhorses were in the intra-island run during the afternoon although some were at both points. On 8 July only one group of redhorses was present, in the dock run around midday; they were involved in spawning behavior considered atypical. No suckers were seen later that day nor on 9 July. Afternoon water temperatures on 24–26 June, preceding the run, were 15.5–17.5°C. During the run they were 17.5–19°C.

In 1968 *M. valenciennesi* first appeared in the dock run on 25 June. We observed spawning on 5–7 July but did not determine the date of termination of spawning. Two males captured on 7 July had shallow bellies and only a small amount of milt could be pressed from them. Because of this, and small numbers and relatively sluggish behavior of redhorses on that date, it appeared that the spawning period was at or very near end. Afternoon water temperature on 15–17 June was 14.5°C and on 23 June, shortly preceding the spawning run, 15.5°C; on 5–7 July it was 16–16.5°C.

In 1970 a few redhorses first appeared in the dock run on 25 June; numbers appeared on 27 June. On 4 July we observed about 20 spawning acts in the dock run during a 2-h afternoon period when about 20 redhorses were present. On 5 July, nine spawnings occurred during a similar period; about eight redhorses were in the dock run most of the period. On 6–7 July no redhorses were seen in the intra-island run; a few were along the upper point on 7 July. One adult, the last seen in 1970, appeared briefly in the dock area during morning of 8 July; it mainly swam slowly and rested in the slow current just below the dock, not in the run. Maximum river temperature on 4 and 5 July was 17°C; on 8 July it reached 18°C.

A brief visit on 22 June 1974 revealed only three adults, all in the run just above the boathouse. Frequently one or more disappeared into deeper water. Apparently the run was starting. Temperatures were not taken; the water seemed relatively cold.

On 4 July 1975 no redhorses were seen in the intra-island run. Based on the relatively high water temperature (20°C), late date, and only small amount of filamentous algae attached to dock run substrate (suggesting most algae had been detached by spawning activity), it is probable that spawning was completed. M. J. Bresnahan informed us that the redhorse run had terminated about 1 wk earlier at nearby islands.

The following ranges of dates (number of days in parentheses) of the spawning runs were estimated from the above data: 27 June – 8 July 1967 (12 d); 25 June to about 8 July 1968 (about 14 d); 25 June to about 7 July 1970 (about 13 d). G. Meikle stated that the redhorse run usually commenced with the appearance of one to few individuals just above the boathouse, and that generally numbers were not present and spawning did not begin in the dock run until 1 or 2 d later. Water temperatures were rising at the start of runs, and during the runs they were generally in the 16–19°C range, with the higher temperatures tending to occur on the later dates.

Local residents seemed to agree that the spawning run of the "redfin mullet" (presumably *M. valenciennesi*) ranged from late June, around the time of full moon, into early July. The peak of the run, when the largest numbers were on shoals, was said to last about 4 d. We were informed that the first appearance of adults in shallows is usually just preceded or accompanied by frequent splashing of redhorses in the cove, often just below the main spawning area. Occasional splashes, not from actual spawning, were made by *M. valenciennesi* throughout our observation periods.

Behavior at the Spawning Site

Redhorses in the dock run were fairly mobile and general swimming and agonistic movements were

always done slowly. Most males stayed below midwater but off the bottom, and moved 3–6 m up- and down-stream and 0.3–1.0 m laterally, usually passing several other males. Occasionally some swam downstream into deeper water below the run, where they often remained for 5–30 min. We were unable to detect clearly any defense of a particular substrate area, although frequent apparent attempts to maintain individual distances were made. When two males came close to each other, about 15 cm apart, one generally pushed slowly, with the head and anterior body, against foreparts of the other. This nudging or blocking was, as often as not, returned by the male first blocked. Females were not noted to nudge or block, but were occasional recipients of these activities, usually away from spawning sites. In such cases perhaps sex initially was not recognized by the male. The failure of females to perform these activities may function as a behavioral method of sex recognition. No interspecific agonistic behavior involving the Greater Redhorse was detected.

Spawning Behavior

Females usually entered spawning sites in the dock run from downstream, occasionally from the boathouse run. Usually only two or three females were in the dock run concurrently. When not spawning, generally they swam about slowly, with movements similar to those of males, or drifted downstream tail first. One female remained in the dock run for about 15 min without spawning. Females were frequently "nuzzled" by males; this behavior involved slow touches or gentle pushes by males with the snout against the anal or closely adjacent areas, rarely in advance of pelvic fins, of females. Nuzzling was often done by one to four males following a female for distances of 1.5–3.0 m through the run. Nuzzling tended to occur more frequently when females were near and over spawning sites than elsewhere in the run. Females did not nuzzle. Nuzzling of females differed from pushing and blocking among males. The latter activities were generally done with the anterior body and lateral parts of the head against these parts of other males.

Females seemed to select the spawning site. They held a position just on or off the bottom at the site for 3–5 s. If not joined by two males during this period, they drifted higher and downstream. Usually they then swam upstream to above the site; occasionally they drifted downstream out of the run.

Spawning occurred when two males were positioned parallel to, and with one on each side of the female, the three facing upstream. Females were almost always slightly to moderately longer than attending males and usually had the head slightly upstream to that of males; occasionally the female was about equal in length to the males. In both situations, the genital pore area of all three was adjacent to each other. Of about 100 consummated spawnings witnessed, only one involved only one male at the start of the act, during which a second male attempted to join the pair, but reached it an instant after termination of the act. During a 2-min period when the same female and one male twice attained spawning position at an often-used spawning site, the male began slow spawning quivers; when the female did not so move, the male ceased the motions after 1–2 s, and no milt was seen. Frequently one to three males attempted to join a spawning trio, by pushing at the dorsum or underside of the original males(s). In one instance, one of the original males was pushed away from a female in the act of oviposition; spawning continued but the intruder did not attain spawning position. Frequently a female in spawning position neglected to spawn when attending males began pushing each other; the males appeared to be vying for the same side of the female. Occasionally a pushing male hastily repositioned himself at a vacant side of the female, and spawning began.

Actual spawning began within 1–2 s after the trio had aligned properly at the bottom. At first the three quivered the body slowly, seemingly synchronously, and then smoothly increased the frequency of vibration to a very rapid, shallow tremoring involving mostly the posterior two-thirds of the body. The duration of 10 acts (quiver and tremor) ranged 2–8 s ($\bar{x}$ = 4.0). During tremor the dorsal and anal fins were spread widely and the pectorals and pelvics were abducted about 90–120°. The most tuberculate areas of males (the anal and caudal fins and the caudal peduncle) were appressed to the female, aiding in position maintenance. The trio usually advanced 3–15 cm upstream during the act. Ova, a milt cloud, and disturbed sand drifted from the group. Some ova were probably buried in the resettled substrate. Upon completion of the act the female usually drifted up off the bottom and downstream tail first, and the males began swimming about slowly, generally away from the site. No parental care or behavioral attachment to the spawning site was seen. No preparation of the spawning site was made, and several acts at any particular site established at most a shallow depression. Spawning and other activity in the run seemed to effect detachment of filamentous algae.

Pre- and post-spawning behavior of three males and one female (each individually recognizable) on the last day (8 July) of the 1967 run differed distinctly from earlier activity. At other times, males usually remained in the dock run and followed females for less than 2 m. In this exceptional case, the males generally followed closely and nudged the female throughout the dock run, and were with her when she frequently

disappeared into and reappeared from deeper water below the run. This activity occurred 11:30–15:50; 25 spawnings occurred, mostly in the earlier part of the period.

Spawning occurred in daylight during mornings and afternoons in the boathouse and dock runs and along the upper point; on the single night of observations it occurred in all these areas. Most spawnings in the dock run were concentrated on the few available sites of gravel, particularly abandoned Fallfish gravel mound nests which became leveled.

Associated Species

Several other fish species were associated with the Greater Redhorse, its spawning habitat, or spawned in nearby habitats at Fishdam Island. Major predators of Greater Redhorse eggs during daylight were the ubiquitous Fallfish, *Semotilus corporalis*, and Yellow Perch, *Perca flavescens*. Ten to 30 individuals of each species often were near spawning redhorses, and others rushed for distances up to 3 m to feed. American Eels, *Anguilla rostrata*, 0.5–1.0 m in length, were seen infrequently in redhorse spawning areas during daylight. During nights they were common to abundant in the spawning areas. Generally they were nosing in the substrate, usually in and near sites of concentrated spawning. Immediately after some redhorse spawning acts, 8–12 eels rushed to the site and the heads of all were on or in the gravel. Two adult White Suckers, *Catostomus commersoni*, were observed concurrently apparently feeding briefly on redhorse eggs once during daylight.

White Suckers congregated 3–4 wk before the Greater Redhorse did so, and spawned for 2–3 wk. Nest-building by the Fallfish, based on dates of discovery of their gravel mounds, preceded the appearance of redhorses by 1–2 wk, and apparently terminated during the early part of redhorse spawning periods. Construction of gravel mound nests by the Cutlips Minnow, *Exoglossum maxillingua*, began about 1 wk before and continued during redhorse spawning periods; a few nests were started at about the end of redhorse spawning. The White Sucker utilized the same open gravel runs for spawning as did redhorses. Fallfish nests were also constructed in these runs, and at the upstream base of the house. Cutlips Minnow nests typically occurred at edges of runs and in very gentle current at sides of the dock; generally nests were closely associated with shelter such as rocks and the underside of the dock.

An adult male in breeding color and a few adult females of the Common Shiner, *Notropis cornutus*, were once seen briefly in the boathouse run when redhorses were present. The activity of the shiners was undetermined. Shortly after, probably the same male appeared for an instant at a Cutlips Minnow nest, from which it was chased by the resident male.

Northern Rock Bass, *Ambloplites rupestris*, were abundant and Smallmouth Bass, *Micropterus dolomieui*, were common at the island; both were over their nests during all of our observations of redhorse reproduction. The Pumpkinseed, *Lepomis gibbosus*, was uncommonly observed; it began nesting near the end of the redhorse run. None of these centrarchids, however, nested in redhorse spawning habitat.

In a zoogeographic study, Jenkins et al. (1972, p.76) remarked that certain habitats around islands in large rivers may harbor populations of fish species not thought to be typical inhabitants of large rivers. This statement was in partial reference to the occurrence of *E. maxillingua* and *N. cornutus* at Fishdam Island.

Acknowledgments

Grace Meikle made this study possible by encouraging our observations on her island, extended numerous courtesies during our visits, provided background information on redhorse reproduction, and took temperatures. The members of the Charles Wart family generously lodged and transported us to the study area. Michael J. Bresnahan gave data on other redhorse spawning sites. We are grateful to Alan R. Emery, Royal Ontario Museum, for critical review of a draft of the manuscript.

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Lichens and Mosses of the Oriskany Sandstone Outcrop, Southern Ontario

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The Oriskany, a middle lower Devonian formation, occurs to a very limited extent in Canada. The one authenticated exposure near Hamilton in southern Ontario provides unusually warm and dry plant habitat and supports the only oak-hickory (*Quercus* sp.–*Carya ovota*) forest on sandstone in the province. Fifteen species of lichens were collected at the outcrop, many of these from exposed rock surfaces. *Cladonia cylindrica* (Evans) Evans is the first record for Ontario. Seventeen species of moss were found, seven of which are new records for the Regional Municipality of Haldimand-Norfolk.

Key Words: mosses, lichens, Oriskany, sandstone, *Cladonia cylindrica*.

The fossiliferous Oriskany outcrop occurs near Nelles Corners, Ontario about 6 km NW of Cayuga and approximately 30 km S of the city of Hamilton. Details concerning location, geology, fossil record, and macrophytic vegetation were published earlier (Fahselt et al. 1979). Although the combination of biological and geological features are unique in Ontario and in Canada, a materials company (Oneida Crushed Stone, a division of the King Paving and Materials of Burlington) has been actively quarrying the outcrop since the fall of 1978. Further, the site plan for quarrying approved by the Ontario Ministry of Natural Resources (Figure 1A) provides that the most unusual portions of the outcrop, from the point of view of macrophytic vegetation, be quarried first. Extraction is now occurring east of McMorran Road near, if not in, sites I and II (Figure 1B).

Access to the outcrop for scientific purposes, other than to a "protection area" is now discouraged. A company directive limits access to geologists who are accompanied by a King Paving employee. It appears that there will be little opportunity in the future to document further biological features of the area. Although Fahselt et al. (1979) noted that mosses and lichens were abundant in some parts of the outcrop, they did not provide any details concerning the cryptogamic flora. My objective in this study was to document which bryophytes and lichens occurred in four homogeneous forested areas when quarrying commenced in 1978.

Method

Samples were taken of all bryophytes and lichens encountered during reconnaisance through four forested sites (Sites I to IV, Figure 1B) whose vascular vegetation was previously analyzed by Paul F. Maycock (Erindale campus, University of Toronto; Fahselt et al. 1979). In sites I and II the overburden was minimal, the soil pH low, conditions generally dry, and the canopy open. Sites III and IV, more typical of southern Ontario, had deeper soil with a circumneutral pH and were more mesic. All collections were made on 27 October 1978. No attempt was made at quantification and data are presented in a presence/absence format.

Frank S. Cook (University of Western Ontario) identified six mosses and verified others I named. Similarly, I. M. Brodo and P. Y. Wong (National Museum of Natural Sciences) assisted with the determination of lichen species. Secondary phenolic compounds used in lichen identification were determined by employing standard TLC techniques of C. F. Culberson (1972, 1974). When several collections of a single species were made, only one per site was retained as a specimen. One voucher per species was deposited at the herbarium of the National Museum in Ottawa (CANL, CANM), and the remainder were retained in the herbarium at the University of Western Ontario (UWO).

Results and Discussion

At the time of the cryptogam collection the four sites remained essentially in the same condition as they were when the vascular vegetation was surveyed in 1977, except that Site I was partially disturbed by the new road system and some trees along McMorran Road had been removed. An "environmental protection area" (EPA) had been set aside by King Paving on the basis of geological criteria and convenience. This included all of Site III and part of Site IV. Neither site contained higher plants that were extraordinary in the Ontario context; III was an unremarkable oak-hickory (*Quercus* sp.–*Carya ovata*) stand and IV was a Sugar Maple (*Acer saccharum*) stand typical of

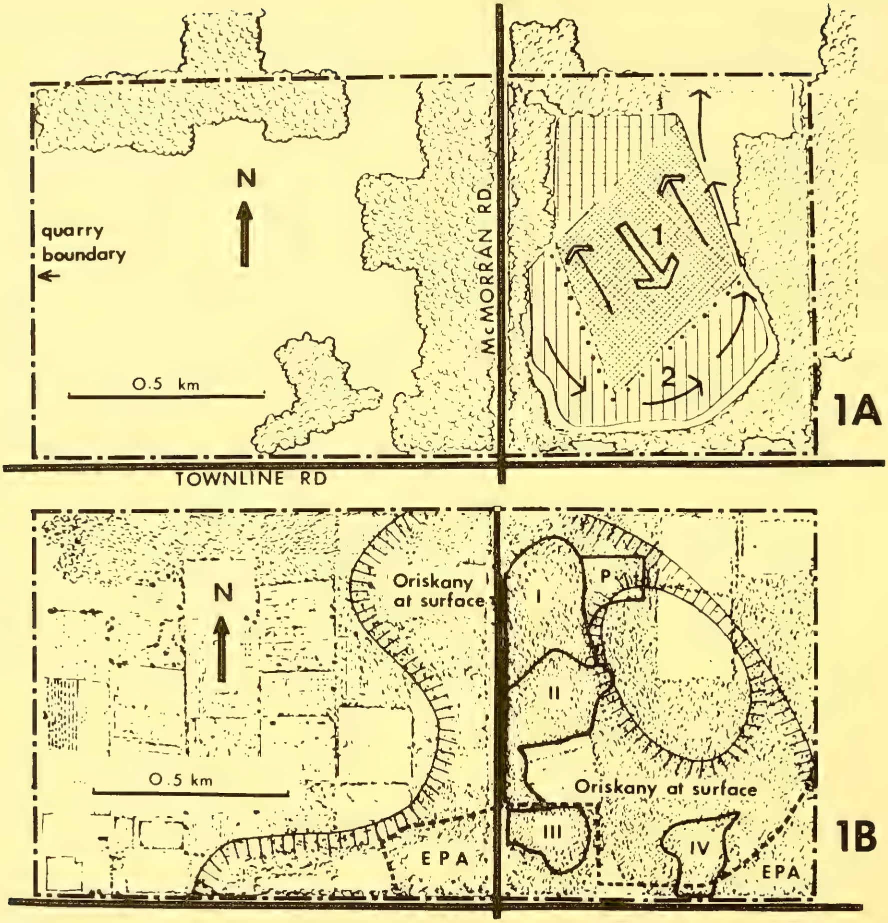

FIGURE 1. A. King Paving and Materials' 202-ha (500-acre) Oneida Quarry as shown on the site plans. The first two of nine sections to be extracted are on the east of McMorran Road. Arrows indicate the direction in which extraction will take place. When sections 1 and 2 have been quarried the most valuable portions of the outcrop from a biological point of view will have been all but obliterated.

B. The four homogeneous forested sites (I–IV) whose vascular vegetation was studied in 1977. Lichens and bryophytes were collected from the same sites for the present study. Although the flora of the open area (P) east of Site I was known to contain a number of unusual and rare prairie elements, it was not possible to obtain cryptogams from this part of the outcrop. The simple broken line shows the extent of the EPA or "environmental protection area." The 121 ha (300 acres) west of McMorran Road is mostly under cultivation or early stages of old field succession.

many in southern Ontario. Sites I and II included the unusual oak-hickory forest and the majority of the rare vascular plants, but neither was designated part of the company's EPA.

Fifteen species of lichens were found, mostly belonging to the genera *Cladonia* and *Peltigera*; these are listed in Table 1 using the nomenclature of Hale (1979). More than half of the lichens occurred either directly on the sandstone or on very thin soil accumulations over it. Most species were not exceptional for Ontario, but *Peltigera elizabethae* was uncommon and normally characteristic of only fairly rich sites (I. M. Brodo, personal communication). The variety of microhabitats available at the outcrop may explain how lichens with diverse requirements could co-exist there. The most notable record was *Cladonia cylindrica*, a first for Ontario (I. M. Brodo, personal communication). *Cladonia norrlinii* was previously recorded only from boreal and semi-arctic Ontario (Ahti 1964) but is also known from special habitats in

TABLE 1—Lichens of Oriskany outcrop near Nelles Corners, Ontario Site

Species	Site I	II	III	IV	Substrate
Cladonia chlorophaea	+				sandstone
Cladonia cristatella				+	fallen log
Cladonia cylindrica[1]				+	fallen log
Cladonia grayi				+	fallen log
Cladonia norrlinii			+		soil
Cladonia pyxidata			+		sandstone
Peltigera canina		+			sandstone
Peltigera canina var. *canina*			+	+	thin soil over sandstone
Peltigera elizabethae			+		sandstone
Peltigera evansiana			+	+	sandstone
Peltigera polydactyla				+	on soil
Peltigera praetextata			+	+	shallow soil, sandstone
Peltigera rufescens				+	sandstone
Physcia millegrana	+	+			bark
Xanthoparmelia cumberlandia				+	sandstone

[1]First record for Ontario.

the Ottawa region (I.M. Brodo, personal communication). Both *P. elizabethae* and *C. norrlinii* occur in Site III and *C. cylindrica* is in Site IV: they are therefore all included in what is currently designated a protection area.

The 17 moss species collected are listed in Table 2 using the nomenclature of Ireland and Cain (1975). Most of the mosses were also found on sandstone or very shallow soil. Exposed rock in southern Ontario is usually part of the Niagara escarpment (limestone or dolostone) and *Hedwigia ciliata* is one moss that rarely grows on calcareous rock (Crum 1973). *Hedwigia ciliata* at the outcrop is thus an indicator of the unusual substrate conditions there.

According to Ireland and Cain (1975) all mosses represent new records for (the former) Haldimand County. Seven are new for Norfolk County as well, i.e., for the Municipality Regional of Haldimand-Norfolk. One of the seven, *Grimmia apocarpa*, has published collection sites in only two other southern

TABLE 2— Mosses collected at the Oriskany outcrop near Nelles Corners, Ontario[1]

Species	Site I	II	III	IV	Substrate
Anomodon attenuatus		+	+	+	sandstone
Anomodon rostratus		+			sandstone
Brachythecium salebrosum (?)	+		+	+	bark, sandstone, soil
Bryum creberrimum	+	+			sandstone
Campylium hispidulum	+				bark
Ceratodon purpureus			+	+	sandstone, thin soil
Entodon cladorrhizans[2]		+			sandstone
Entodon seductrix[2]		+			decaying wood
Grimmia apocarpa[2]		+		+	sandstone
Hedwigia ciliata[2]	+		+	+	sandstone
Plagiomnium cuspidatum		+	+	+	sandstone, shallow soil
Plagiomnium medium[2]	+				soil
Polytrichum juniperinum	+		+		shallow soil, sandstone
Polytrichum piliferum[2]	+			+	sandstone
Rhodobryum ontariense[2]	+				sandstone
Thuidium recognitum		+	+		soil
Tortula ruralis			+		sandstone

[1]All are new records for Haldimand County, Ontario, according to Ireland and Cain (1975).
[2]No record in either Haldimand or Norfolk County (Ireland and Cain 1975).

Ontario counties, Middlesex and Brant. Of the species new for the region all were collected in the ill-fated Sites I and II while three were found in Sites III or IV (within the EPA). Quarrying will thus have a significant detrimental effect on the bryophyte flora of the Oriskany outcrop.

Not only is the unusual habitat in Sites I and II in jeopardy, but the security even of the EPA can be questioned. The Minister of Natural Resources, James Auld, has already removed one of the conditions that was imposed on the company when the license to quarry was granted. Thus the requirement for the company to maintain the EPA could be lifted as well. To ensure that this does not occur, the area should be made part of the provincial Nature Reserve system.

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Pollination of the Small White Lady's-slipper (*Cypripedium candidum*) in Lambton County, Southern Ontario

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Catling, P. M. and G. Knerer. 1980. Pollination of the Small White Lady's-slipper (*Cypripedium candidum*) in Lambton County, southern Ontario. Canadian Field-Naturalist 94(4): 435–438.

Andrenid and halictine bees 6–7 mm in length appear to be the most important pollinators of *Cypripedium candidum* in a native prairie. Experiments indicate that effective pollinator size is restricted by the dimensions of the entrance and exit passages of the semi-trap blossom. On the path of escape the dorsal surface of the thorax of the appropriate bee-pollinator will come into contact first with the stigmatic surface and subsequently with the anther. Three *Andrena ziziae* females, one female of a *Sphecodes* sp., one female of a *Nomada* sp., a small hymenopterous parasite (Chalcididae), and a beetle (Elateridae) were found inside flowers. Females of *Augochlorella striata, Halictus confusus, Dialictus rohweri, D. atlanticus,* and *D. pilosus* were observed carrying *C. candidum* pollen on the dorsal surface of the thorax. A local diversity of wildflowers may influence the fecundity of *C. candidum* through its effect on abundance and diversity of pollinators.

Key Words: *Cypripedium candidum*, orchid, pollination, southern Ontario, prairie, bees, Andrenidae, Halictidae.

The Small White Lady's-slipper (*Cypripedium candidum*) is a rare species, confined to midwestern and a small portion of eastern North America (Luer 1975). It is primarily a plant of wet and mesic prairies but occurs also in open fens and swampland edges. It is considered either rare, threatened, endangered, or extinct in the various parts of its range (Argus and White 1977; Kartesz and Kartesz 1977), and is the only vascular plant protected under the Ontario Endangered Species Act (McKeating and Bowman 1977).

The lip in flowers of the various *Cypripedium* species acts as a semi-trap controlling the pathway of bee-pollinators through the flower (Pijl and Dodson 1966; Stoutamire 1967). The dimensions of entrance and exit passages are selective with respect to pollinator size, and bees of appropriate size entering the large distal opening are prevented from leaving the same way by the reflexed margins and smooth inner walls. Escape is possible by either of two small openings at the base of the lip. Reddish or purple lines, long hairs and windows at the back of the lip usually mark this route, and such is the case in *C. candidum* (Figure 1A, B). On the path of escape the dorsal surface of the thorax of the bee contacts first the stigmatic surface thereby depositing any pollen resulting from a previous visit to a flower. As the bee continues along the passage stiff hairs on the lip push it closely against the anther. A sticky mass of pollen is deposited on the dorsal surface of the bee's thorax as it forces its way through the passage.

Both color and odor probably play a role in attracting pollinators. Nectar and other food substances are apparently lacking in the flowers which are often described as "attracting by deceit" (Pijl and Dodson 1966; Stoutamire 1967).

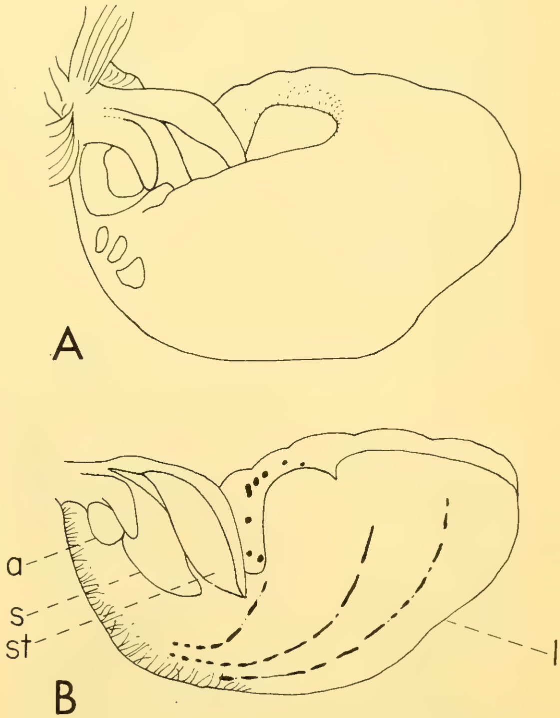

FIGURE 1. Lip and column of *C. candidum*. A, as viewed from outside. B, with one side of lip cut away to show internal path of pollinator; (a, anther; s, stigma; st, staminodium; l, lip).

There is no previous record of the pollination of *C. candidum* under natural circumstances. In spite of numerous visits to wild colonies, Stoutamire (1967) observed pollination only once. This involved a female of *Andrena placida* and a group of cultivated plants in Oakland County, Michigan.

Methods

In view of the lack of information on the pollination of this rare orchid, an attempt was made to gather data during visits to the Pinnance Prairie on Squirrel Island (42° 35.5′N, 82° 35′W) Lambton County, Ontario, on 28 and 31 May 1979. At this location 2000–3000 plants were scattered through a rich open prairie 1.2 ha in extent. This small area, leased for protection by the Michigan Nature Association, is one of the finest prairie stands left in southern Ontario with about 300 native species listed to date (Michigan Nature Association, 124 Miller Street, Mount Clemens, Michigan 48043, personal communication). The Small White Lady's-slippers were in late peak of flowering during our visits.

Flowering plants were observed and insects associated with the flowers were collected. Insects visiting the flowers of other species were captured, anesthetized with CO_2 and examined for *C. candidum* pollen. A variety of live bees was introduced experimentally into the lips in order to observe their subsequent behavior.

Bees were identified by G. Knerer using Mitchell (1960) or more recent work. *Andrena ziziae* was determined by W. E. LaBerge of the University of Illinois, Urbana. Voucher specimens are contained in the collections of the Department of Zoology at the University of Toronto, Department of Entomology at the Royal Ontario Museum and Entomology Section

FIGURE 2. *Andrena ziziae* emerging from the basal orifice of a *C. candidum* lip with a sticky mass of pollen from one of the lateral anthers being deposited on its thorax.

of the Research Branch at Agriculture Canada in Ottawa.

Results and Discussion

On 28 May, one *Andrena ziziae* was collected as it emerged from a basal opening of a lip and another was found dead in the exit passage. In addition a *Sphecodes* sp. and a *Nomada* sp. were found inside lips. On 31 May, another *Andrena ziziae* was found inside a lip, as well as a beetle (Elateridae) about 8.5 mm in length. A small hymenopterous parasite (Chalcididae) about 3.5 mm long was found with a *C. candidum* pollen smear on its dorsal thorax and glued by this onto the stigmatic surface. The anthers of this flower appeared undisturbed so that the fly had apparently cross-pollinated the blossom. Female bees carrying *C. candidum* pollen on the dorsal thorax included one *Augochlorella striata*, four *Halictus (Seladonia) confusus*, one *Dialictus rohweri*, one *Dialictus atlanticus*, and one *Dialictus pilosus*. These were collected while they were visiting flowers of *Zizia aurea* and *Sisyrinchium mucronatum*. *Andrena ziziae* and *Halictus confusus* were among the most common bees and may represent the principal pollinators of *C. candidum* at this site.

Certain other bees were present in the area, including *Halictus ligatus, Agapostemon radiatus, Dialictus cressonii, D. lineatulus, D. nymphaearum, Andrena erythrogaster, Ceratina calcarata* but none of these were observed with *C. candidum* pollen.

Females of *Augochlorella striata, Andrena ziziae,* and *Dialictus rohweri* (all about 6–7 mm in length) were placed inside the lip of freshly opened *C. candidum* flowers. In all cases they took 5–15 min to exit and crawled out with apparent difficulty, their progress being impeded by the stiff hairs along the exit passage. Some of these small bees tried to escape through the distal opening but the inflexed margins and smooth inner walls, coupled with their small size made it impossible. Examination of the distal portion of the lip took 2–7 min, with 3–8 min taken to squeeze out of the exit passages. All of these smaller bees emerged with a sticky green pollen smear on the thorax (Figures 2, 3). Specimens of the larger bee, *Agapostemon radiatus* (about 10.5 mm in length) were able to escape easily through the distal opening and probably were too large to force their way out of the basal exit passages.

Of 400 slightly withered and discolored flowers on Squirrel Island checked on 31 May, 92 or almost 25% had been pollinated, and in most of these flowers the pollen of either *Zizia aurea* or *Sisyrinchium mucronatum* had been rubbed off onto the hairs along the exit passages.

Halictine and andrenid bees, 6–7 mm long, are obviously well suited to the pollination of *C. candidum*. They are especially numerous in the spring when the overwintered females provision the brood cells with pollen and nectar. As a group these bees are not very host specific, being found on a variety of Asteraceae, Salicaceae, Apiaceae and other flowers with pollen and nectar readily accessible to their short tongues. The short life span of some andrenid females has resulted in a consistent dependence upon a small number of flowering plants. For example, *Andrena ziziae* appears to be closely associated with *Zizia aurea* (Mitchell 1960), but also visited *Sisyrinchium mucronatum* in our study area. Halictines such as *Dialictus rohweri* and *Augochlorella striata* are social and produce one or several broods of smaller workers before the males and queens are reared in late summer. This long activity period results in association with many plant species. It appears that the bee pollinators include not only industrious species, but

FIGURE 3. *Andrena ziziae* with pollen smear from *C. candidum* on thorax.

also parasites or cuckoo bees, like *Sphecodes* (on halictines) and *Nomada* (on *Andrena*). Other insects (e.g., elaterid beetles and chalcid wasps) may participate as supplementary pollinators.

Cypripedium candidum can reproduce vegetatively, but its success on the Pinnance Prairie is probably due in part to the dispersal of seeds and therefore the activity of pollinating bees (since there is no evidence of seed production without pollination). Fecundity may vary from year to year depending upon the timing of spring and the consequent overlap of *C. candidum* with other showy flowers providing pollen and nectar. Some of the bee pollinators (e.g., *Andrena ziziae*) are apparently dependent upon the food-providing species that flower with *C. candidum,* while others, including the halictines probably depend upon a continuity of blossoms providing pollen and nectar throughout the spring, summer, and autumn. Thus the diversity of showy wildflowers on the prairie, with at least a few species in full bloom at any one time, may influence the success of *C. candidum* through its effect on the abundance and diversity of pollinators.

Acknowledgments

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John Goldie's 1819 Collecting Site near Lake Simcoe, Ontario

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John Goldie travelled through parts of what is now Ontario in 1819 and thus was one of the first botanical explorers to visit the province. One of the richest collecting sites he found during his travels was near Lake Simcoe in the vicinity of the present town of Holland Landing. Here, Goldie reported six species: *Drosera linearis* (Linear-leaved Sundew), *Ranunculus rhomboideus* (Prairie Buttercup), *Betula pumila* var. *glandulifera* (Swamp Birch), *Asclepias tuberosa* (Butterfly-weed), *Euphorbia corollata* (Flowering Spurge), and *Lonicera hirsuta* (Hairy Honeysuckle). Of these, the *Drosera* and *Ranunculus* were new to science. In 1976, this site was re-discovered. It is an area of remarkable botanical interest with numerous regionally rare species. The site comprised a sand plain with dry open ground dominated by numerous species of sandy prairie, dune and 'barrens' affinity adjacent to a large Tamarack (*Larix laricina*) swamp with rich fen openings. Of the species reported by Goldie, only the *Drosera* and *Asclepias* were not found. In addition to its historical significance, Goldie's work was important because it established the presence of prairie or prairie-like communities in central Ontario well before extensive land-clearing by Europeans.

Key Words: botanical exploration, type localities, Ontario, phytogeography, rare species, prairie, vegetational history.

John Goldie (1793–1886) was one of the first botanical explorers in Ontario, preceding even the more famous David Douglas and John Richardson (Voss 1978). Goldie visited Ontario in 1819 and, although he did not describe large numbers of new species, his trip was important because it was one of the first by a trained botanist. One of Goldie's richest sites was located "near Lake Simcoe" (Goldie 1822), near the present-day town of Holland Landing, York County, Ontario. The re-discovery of this site and its floristic and vegetational significance are here reported.

Goldie's Field Work

Goldie was trained at the Botanical Gardens at Glasgow and was a friend of Sir William Hooker. At Hooker's urging, he went to North America in June 1817 and stayed until September 1819, then returned to Great Britain. After he had been in Great Britain for a few years, he went to Russia to collect plants for the Botanical Garden at St. Petersburg (Leningrad). Later, in 1844, he came back to Ontario with his family and settled near Ayr, remaining there until his death at the venerable age of 94. Little is known of Goldie's life after he returned to Ontario in 1844 but it seems he retained only a casual interest in botany (Ewan 1968). Although Goldie botanized for three summers in eastern North America, only the travels of the summer of 1819 are of botanical importance because the specimens he collected the previous two summers were regrettably lost, presumably at sea. Goldie's trip of 1819 began 4 June at Montreal, took him through part of southern Ontario, Pennsylvania, and New York and ended in mid-September, back at Montreal. This journey was described in detail in his diary (Goldie 1897; Spawn 1967). The botanical results of this trip were described a few years after Goldie returned to Great Britain (Goldie 1822).

During this trip, Goldie took a detour 60 km (37 mi) north from Toronto, Ontario to near the south end of Cook's Bay, Lake Simcoe. There, from 27 June to 5 July, he stayed along the Holland River near "the upper landing place . . . at the farthest house upon this road" (Goldie 1897). The upper landing on the Holland River was about 2.4 km (1.5 mi) downstream from the present town of Holland Landing, on the east side of the Holland River (Hunter 1948). This area Goldie found particularly interesting: "Since I came here I have seen a number of rare plants and some of them are non-descripts . . . If a person could spend a season here he might expect to find many plants not yet described" (Goldie 1897). This site clearly was one of the highlights of Goldie's summer travels as he mentions species he found there and discusses it in considerable detail in his diary.

Fourteen new species were described by Goldie (1822) from his 1819 collections. Three of these were wholly or in part based on material from Holland Landing. These were *Caprifolium pubescens* (Hairy Honeysuckle), *Drosera linearis* (Linear-leaved Sundew), and *Ranunculus rhomboideus* (Prairie Buttercup). *Caprifolium pubescens*, described from "near Kingston and near Lake Simcoe," is a synonym of *Lonicera hirsuta* but the other two, both described only from "near Lake Simcoe," are familiar to all botanists in the Great Lakes area. In addition to these three, Goldie mentions *Betula glandulosa* (Dwarf Birch) at the site, noting even then the taxonomic problems surrounding this species and *B. pum-*

ila (Swamp Birch). The Holland Landing plants would be referred now to *B. pumila* var. *glandulifera* (Fernald 1950) or *B. glandulosa* var. *glandulifera* (Gleason and Cronquist 1963). Goldie also reported three species in his diary: "a species of *Asclepias* with orange flowers very handsome, a species of *Euphorbium* with white flowers, a *Ranunculus* . . . " The *Ranunculus* is certainly Goldie's *R. rhomboideus* and there can be no doubt that Goldie's *Asclepias* and *Euphorbia* were *Asclepias tuberosa* (Butterfly-weed) and *Euphorbia corollata* (Flowering Spurge) as they are the only Ontario species of these genera with respectively, showy orange and white flowers. All six species noted by Goldie were quite rare regionally and were reported with good reason.

These species are of particular significance since several are indicators of very specific habitats in southern Ontario. The *Ranunculus*, *Euphorbia*, and *Asclepias* are all indicators of open, dry, sandy soil; in Ontario mostly prairie or open dunes and oak savanna with prairie affinities. The *Drosera* is specific to rich open fens. Only the *Betula* and *Lonicera* are of relatively broad ecological amplitude. The open character of the dryland habitats here is further supported by Goldie's (1822) description of *Ranunculus rhomboideus* as occurring "in dry sandy fields."

The Site Today

Now, 157 years later, during the course of field work in northern York County in 1976, I also found a remarkable assemblage of plants along the east side of the Holland River about 2.4 km (1.5 mi) downstream from the town of Holland Landing.* Here there was a small, more or less flat sand plain between the river and a series of low hills about 1 km (0.6 mi) to the east. The sand deposits extended in tongues nearly to the banks of the Holland River in places and one of those tongues apparently formed the "Upper Landing" mentioned by Goldie (1897). Where not developed for housing, several hundred hectares of this dry sandy soil was occupied by an open, prairie-like community of *Andropogon gerardii* (Big Bluestem), *A. scoparius* (Little Bluestem), *Danthonia spicata* (Poverty Grass), *Carex foenea* (Sedge), *Corylus americana* (American Hazel), *Ceanothus americanus* (New Jersey Tea), and scattered *Populus grandidentata* (Large-toothed Aspen) (Figure 1). Some areas were somewhat disturbed and weedy with much *Sporobolus cryptandrus* (Sand Dropseed), *Poa compressa* (Canada Bluegrass), and *P. pratensis* (Kentucky Bluegrass) and other areas graded into dense forests of *Quercus rubra* (Red Oak), *Q. alba* (White Oak), and *Pinus strobus* (White Pine). An unfortunately large portion has also been reforested with various conifers. Accompanying these dominants was a large number of species, predominantly of sandy prairie, dune, and 'barrens' communities. Although some of these plants are widespread and common species of open ground, a substantial portion are rare in this inland region of central Ontario (Table 1).

Between the sand plain and the river lies an extensive, wet *Larix laricina* (Tamarack) swamp with small areas of open fen. These openings were dominated by *Potentilla fruticosa* (Shrubby Cinquefoil), *Betula pumila* var. *glandulifera*, *Scirpus acutus* (Hard-stem Bulrush), *S. hudsonianus* (Alpine Cotton-grass), and *Carex lasiocarpa* (a sedge). The Tamarack swamp and especially the associated fen openings also harbored a number of regionally rare species (Table 1).

For a number of species such as *Selaginella rupestris* (Rock Spikemoss), *Cyperus houghtonii* (Galingale), *Scirpus hudsonianus*, and *Carex richardsonii* (a

TABLE 1—Regionally rare species at John Goldie's Holland Landing collecting site of 1819 (Reznicek's collections 1976–1979, specimens in TRTE, TRT and MICH)

Sand plain	Tamarack swamp and fen openings
Selaginella rupestris	**Triglochin maritimum*
Botrychium simplex	*Calamagrostis stricta*
Bromus kalmii	*Scirpus hudsonianus*
Oryzopsis pungens	*Eriophorum gracile*
Panicum praecocius	*Carex chordorrhiza*
Cyperus houghtonii	*Carex livida*
Carex foenia	*Platanthera dilitata*
Carex richardsonii	*Salix pedicellaris*
Zigadenus glaucus	*Betula pumila* var. *glandulifera*
**Lilium philadelphicum*	*Potentilla fruticosa*
Corylus americana	*Utricularia minor*
Ranunculus rhomboideus	**Lonicera oblongifolia*
Prunus besseyi	**Lobelia kalmii*
Amelanchier alnifolia var. *alnifolia*	**Aster junciformis*
Euphorbia corollata	
Rhus aromatica	
Ceanothus americanus	
Ceanothus herbaceus	
Helianthemum bicknellii	
Helianthemum canadense	
Viola fimbriatula	
Arctostaphylos uva-ursi	
Calystegia spithamea	
Lonicera hirsuta	
Helianthus rigidus	
Aster laevis	

*Sight record only, no voucher collected.

*The actual location of the site is Ontario, York County, East Gwillimbury Township, Concession I W, lots 111–115, about 2.4 km (1.5 mi) NNW of Holland Landing; 44°07′N, 79°30′W.

FIGURE 1. Stand of *Andropogon gerardii*, *Ceanothus americanus*, *Carex foenea*, and *Danthonia spicata* near Holland Landing, Ontario. Conifers in background are *Pinus sylvestris* (Scots Pine) planted by the Ontario Ministry of Natural Resources. The *Pinus* are choking out the native species. Photo by author, 29 September 1976.

FIGURE 2. *Ranunculus rhomboideus* at type locality, near Holland Landing, Ontario. Photo by D. R. Gregory, 11 May 1977.

sedge), this is the only known site in York County. For others, like *Rhus aromatica* (Fragrant Sumach), *Euphorbia corollata*, and *Amelanchier alnifolia* var. *alnifolia* (Saskatoon) (S. M. McKay, personal communication) this is the only known station for a radius of over 100 km (60 mi). For *Prunus besseyi* (Sand Cherry), the nearest stations are in southern Manitoba and adjacent Minnesota (Fernald 1950; S. M. McKay, personal communication), a major disjunction paralleling that of *Opuntia fragilis* (Prickly Pear) (Beschel 1967). Also, the juxtaposition of boreal conifer swamp and prairie-like vegetation is very unusual in southern Ontario.

As can be seen from Table 1, four of the six species reported by Goldie (1822, 1897) were noted at this site. *Betula pumila* var. *glandulifera* was a dominant of openings in the Tamarack swamp. *Lonicera hirsuta* was scarce in dry sandy open ground at the edges of dense forest. *Ranunculus rhomboideus* (Figure 2) and *Euphorbia corollata* were abundant in dry open sandy soil with *Andropogon gerardii, A. scoparius, Carex foenea, Corylus americana, Danthonia spicata*, and *Ceanothus americanus*. This is the only extant station for the *Ranunculus* and *Euphorbia* in York County. The *Euphorbia* has never been found elsewhere in the region and the *Ranunculus* has not been reported at High Park, Toronto, its only other station, since 1933 (Wainio et al. 1976). *Lonicera hirsuta* is a very rare plant in York County and *Betula pumila* var. *glandulifera* is rare and present only in the northern half of the county (Soper and Heimburger 1961). In spite of assiduous searching, *Drosera linearis* and *Asclepias tuberosa* were not found. At present the *Drosera* is not known to occur south of the immediate shores of Georgian Bay in Ontario (Cruise and Catling 1974).

The correlation of habitats and the combination of species rare in the region leaves no doubt that this was the precise location that John Goldie happily botanized over a century and a half ago. There can also be no doubt that this was the type station of *Ranunculus rhomboideus* and that the type locality of *Drosera linearis* was in the adjacent fen openings.

Goldie's work had additional value even beyond his discoveries of new species. Although the number of species mentioned by Goldie are few, the ones he does mention were all rare or local and most were indicators of very specific habitats. Highly reliable inferences about the ecology of the site can be deduced from their presence. In fact, probably the most significant aspect of his work was to confirm the existence of prairie or certainly prairie-like conditions this far east and inland in Ontario well before extensive land clearing by Europeans. Also, even though the habitats are still present in a form very like what Goldie saw, his reports of species no longer present suggests an even richer flora in the past. With the large number of rare plants still present at this site with over a century and a half of man's depredations, one can only wonder in awe at what botanical splendor Goldie saw during his short visit.

Acknowledgments

I thank Paul Catling (Department of Botany, University of Toronto) for his helpful comments on the manuscript and on the abundance and distribution of rare species in the York County region. Thanks also go to Sheila McKay (Department of Botany, University of Toronto) for determining the specimens of *Prunus besseyi* and *Amelanchier alnifolia* var. *alnifolia* and providing information about their distribution.

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The Genus *Listera* (Twayblades) in New Brunswick

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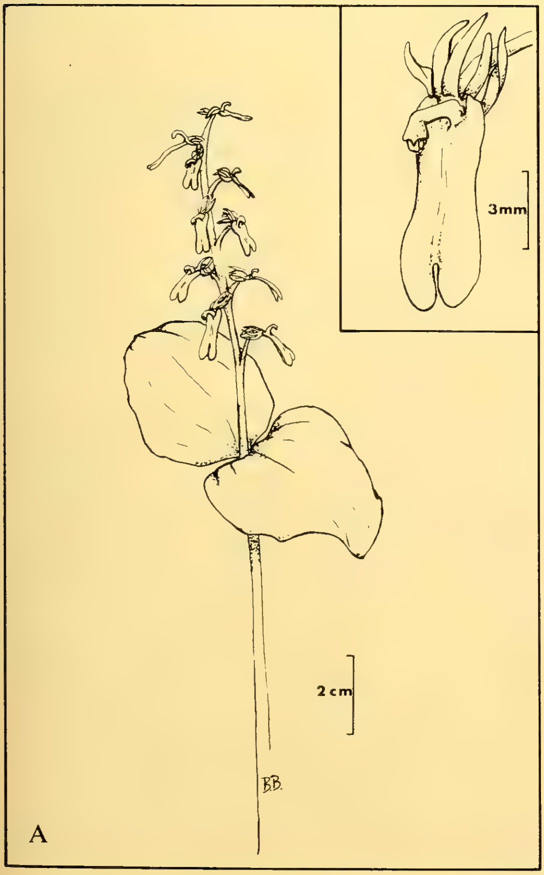
Cody, William J. and Derek Munro. 1980. The genus *Listera* (Twayblades) in New Brunswick. Canadian Field-Naturalist 94(4): 443–446.

The occurrence and habitats of four species and one putative hybrid of the genus *Listera* (Twayblades) in the province of New Brunswick are documented. *Listera australis* is reported as new to the province.

Key Words: *Listera*, Twayblades, New Brunswick, geographical distribution, new records, habitat, hybrids.

The discovery of *Listera australis*, Southern Twayblade, new to the province of New Brunswick, while we were conducting a survey of the vascular plants of Kouchibouguac National Park, led us to examine other members of the genus. Four species, *L. auriculata, L. australis, L. convallarioides*, and *L. cordata*, and one hybrid, *L.* × *veltmanii* are now known to occur in the province. Of these, the putative hybrid is known from 2 sites, *L. australis* is known from 1, *L. auriculata* from 9, *L. convallarioides* from 15, and *L. cordata* from 20.



Species of Listera

Listera auriculata, Auricled Twayblade (Figure 1A)

Known from Gloucester, Madawaska, Restigouche, Victoria, and York counties (Figure 1B). This is a northeastern North American species which is found in Canada from Newfoundland to Thunder Bay District, Ontario, and Manitoba (Singush Lake, 51°36′N, 100°48′W, *Rowe 668* (DAO)), south in the United States to New England, New York, Michigan, Wisconsin, and Minnesota (Fernald 1950). A map of the Canadian distribution which does not show any collections from New Brunswick, is given by Whiting and Catling (1977). This species occurs mainly in the northern and western parts of the province where it is found on flood plains of streams, in alder (*Alnus* sp.) thickets, hardwood and softwood stands.

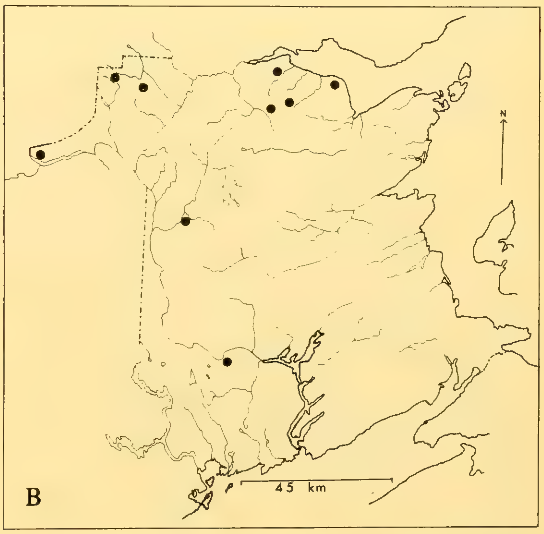
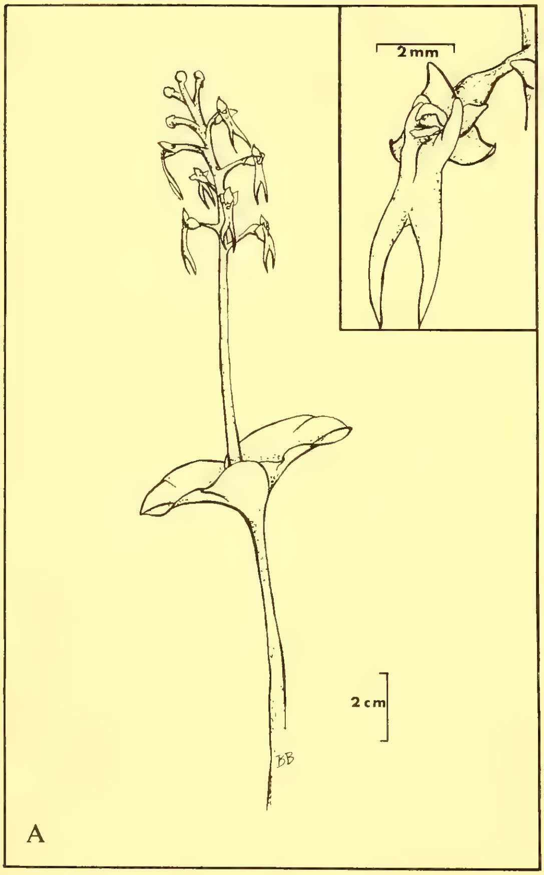


FIGURE 1A, *Listera auriculata*. 1B, Distribution of *Listera auriculata* in New Brunswick.



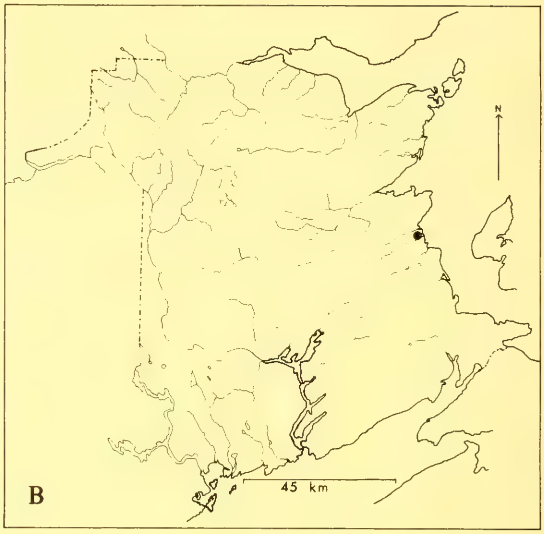


FIGURE 2A, *Listera australis*. 2B, Distribution of *Listera australis* in New Brunswick.

Listera australis, Southern Twayblade (Figure 2A)

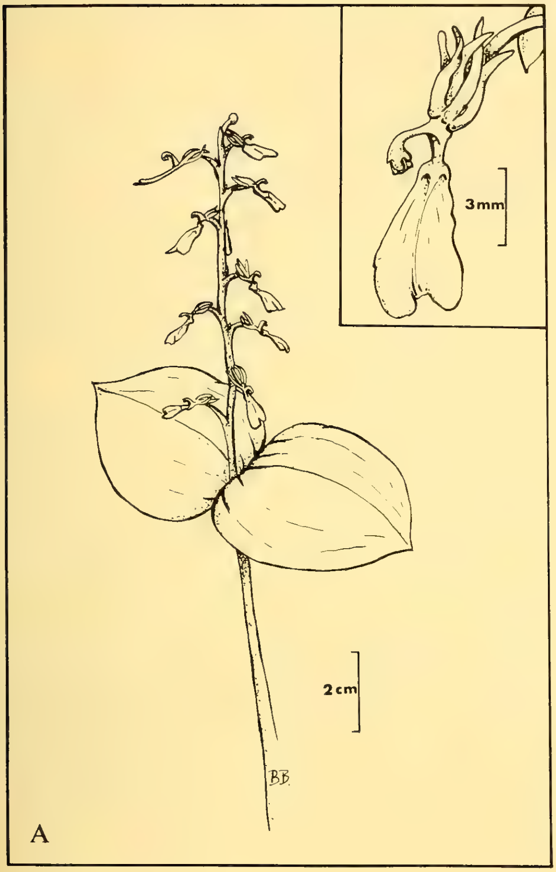
Known from Kent County only: Kouchibouguac National Park, along the periphery of Kelly's Bog, *D. M. Wood*, 27 June 1977 (DAO) (Figure 2B). New to New Brunswick. This is an eastern North American species which is found from eastern Texas and Florida north to New Brunswick, Cape Breton Island, Nova Scotia (Whiting 1971), New Brunswick, southern Quebec (Greenwood 1962; Mousley 1940), and southern Ontario (Whiting and Bobbette 1974). A map of the known Canadian distribution was given by Whiting and Bobbette (1974). The species is very rare in New Brunswick where at its only known locality it grows in flat moist sphagnum with Three-leaved False Soloman's Seal (*Smilacina trifolia*) and stunted Black Spruce (*Picea mariana*) at the edge of a bog.

Listera convallarioides, Broad-leaved Twayblade (Figure 3A)

Known from Gloucester, Kent, Madawaska, Restigouche, St. John, Victoria, and York counties (Figure 3B). This is a boreal North American species which is found across Canada from Newfoundland to British Columbia, thence southward in New England and in the west at higher elevations to Arizona (Luer 1975). Widespread over the province, but nowhere common. At Kouchibouguac National Park this species was found in wet usually organic soils under the medium shade of White Cedar (*Thuja occidentalis*); elsewhere in the province it occurs in a variety of habitats: damp sphagnum at the edge of cedar bogs, conifer woods, hardwood and softwood floodplains and bottomland, and damp mossy woods.

Listera cordata, Heart-leaved Twayblade (Figure 4A)

Known from Carleton, Charlotte, Gloucester, Kent, Madawaska, Northumberland, Restigouche, Victoria, Westmorland, and York counties (Figure 4B). This is a circumboreal species which in North America is found across Canada from Newfoundland and Labrador to British Columbia, southwestern District of Mackenzie, and southern Alaska, in the east southward to western North Carolina, and in the west southward in the mountains to northern California and northern New Mexico (Luer 1975). In Kouchibouguac National Park this species was locally common in White Cedar bogs and infrequent elsewhere in moss in wet bottomland. It is the most frequently found species of *Listera* in the province and may be found in mossy soil in hard- and soft-woods to damp sphagnum in Balsam Fir (*Abies balsamea*), Spruce (*Picea* sp.), and White Cedar woods.



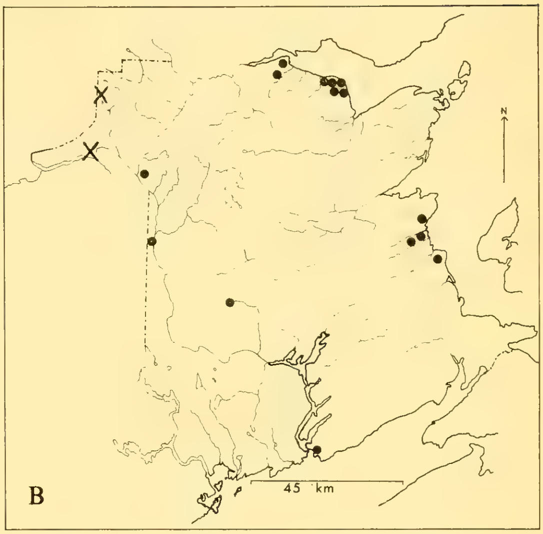


FIGURE 3A, *Listera convallarioides*. 3B, Distribution of *Listera convallarioides* in New Brunswick. The hybrid *L.* × *veltmanii* is shown as ×.

Listera × *veltmanii (L. convallarioides* × *auriculata)* Hybrid (Figure 5),

Known from Madawaska County. This putative hybrid could be anticipated wherever the two parents might occur adjacent to each other. Luer (1975) knew it only from the type locality in Alger County, Michigan. Catling (1976) reported it from 10 widely separated sites in Newfoundland, New Brunswick, Quebec, Ontario, and Michigan and we have seen a specimen from Coos County, New Hampshire (UNB). Catling (1976) mapped a specimen (*A. A. Eaton*, July 11, 1904, Mountain back of Claire, New Brunswick (AMES)) in Kent County, which however, in our opinion, was collected in Madawaska County. Another specimen (*Cunningham & Loucks*, July 22, 1960, 2½ mi W of Summit Depot, Madawaska County (DAO)), was, in Catling's opinion, atypical, and perhaps represented a backcross with *L. convallarioides*.

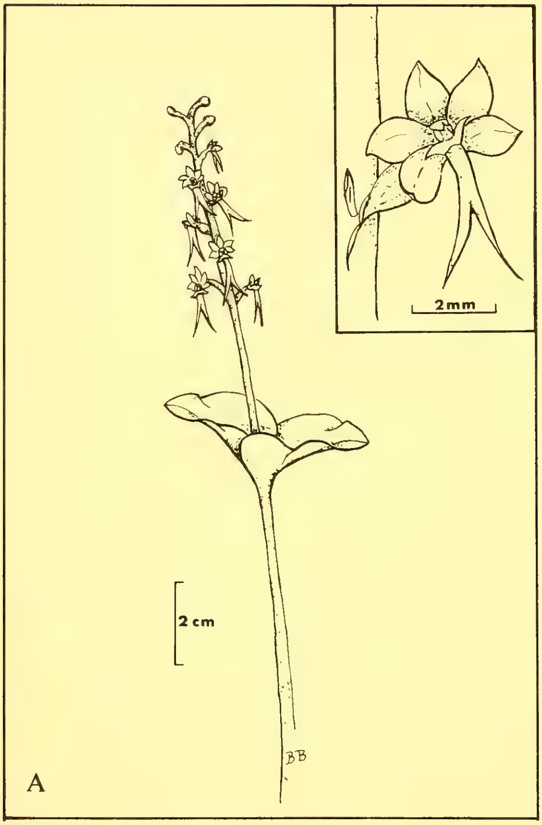
Identification Key

This key will help with the identification of the species of *Listera* found in New Brunswick.

Column of the flower no more than 1.0 mm long; lip deeply cleft into pointed linear-lanceolate lobes
- Lip with a tooth on each side at the base; rachis and pedicels glabrous .... *L. cordata* (Figure 4)
- Lip auricled at the base; rachis and pedicels glandular .... *L. australis* (Figure 2)

Column of the flower more than 1.5 mm long; lip pear-shaped or oblong, shallowly notched or cleft no more than one-third its length
- Lip with a short claw, without basal auricles extending beyond the column
  - Base of lip with an indistinct auricle on each side; lip shallowly notched .... *L. convallarioides* (Figure 3)
  - Base of lip with a distinct auricle on each side; lip deeply cleft .... *L.* × veltmanii (Figure 5)
- Lip sessile with basal auricles extending beyond the column .... *L. auriculata* (Figure 1)

The distribution maps are based on specimens from the following herbaria: CAN, DAO, UNB.



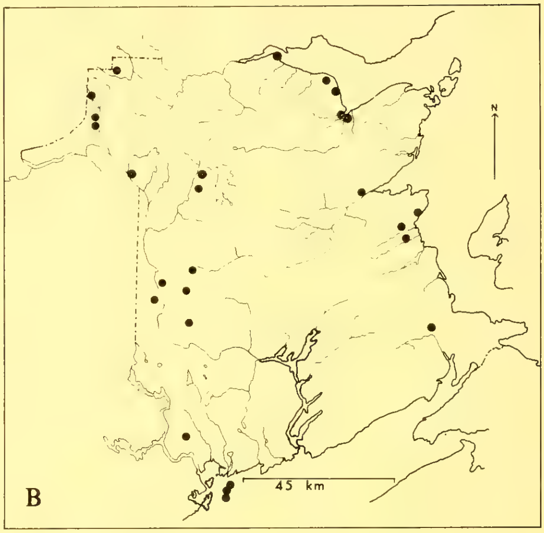


FIGURE 4A, *Listera cordata*. 4B, Distribution of *Listera cordata* in New Brunswick.

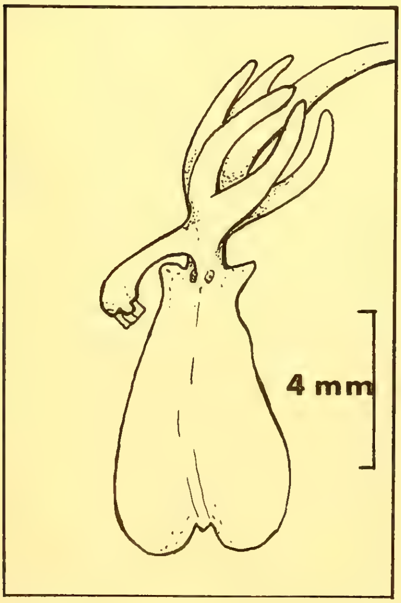


FIGURE 5. Lip of *Listera* × *veltmanii.*

Acknowledgments

Special thanks are given to Brenda Brookes for the preparation of the fine line-drawings which accompany this paper. The loans of specimens from the National Museum of Natural Sciences, Ottawa, and the University of New Brunswick, Fredericton, are much appreciated. Also, locality data provided by Paul Catling was most helpful.

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A Specialized Apparatus for Close-up Nature Photography[1]

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Johnston, James A. 1980. A specialized apparatus for close-up nature photography. Canadian Field-Naturalist 94(4): 447–450.

A close-up photographic apparatus that was designed to give consistently good photographs of live reptiles and amphibians either in the field or laboratory is described. Also represented are several accessory adaptations, including a plexiglass tank for aquatic specimens and a facility to triple the bellows magnification at all extensions.

Key Words: macro-photography, nature, flash, field, laboratory.

The idea for this equipment evolved in response to a need to produce consistently good and comparable color photographs of live reptiles and amphibians, either in the field or in the laboratory. The need for consistency, portability, and ease of use defined from the outset the characteristics of the equipment.

To eliminate the need for constant color corrections from varied light sources, a self-contained light source was necessary. This apparatus uses two electronic flashes; the main flash is a Honeywell Strobonar 782; a Braun F34R functions as a fill light. This use of two flashes provides a better modeling effect; that is, it depicts the shape better. The Strobonar is equipped with an opaque dome, which softens and spreads the light and reduces unwanted highlights. The other photographic equipment used is manufactured by Asahi Pentax; however, similar equipment is available in most commercial photographic lines. The camera part of the apparatus consists of a 35-mm Pentax SP1000 camera, an automatic bellows, and a 100-mm Bellows Takumar f/4 lens. The bellows lens itself does not focus but is designed to work as a "macro"-style lens in conjunction with the bellows. Thus, when the bellows is not extended, the focus is at infinity, and when it is fully extended, the film-to-subject distance is 40.9 cm. The apparatus set up in this manner is, however, effective only between 104.4 and 40.9 cm; that is, it produces images from 0.12× life size to 1.32× life size. The maximum range of 104.4 cm rather than infinity is due to the restrictions imposed by trying to keep the flash bracket compact and portable in the field. The use of the 100-mm lens provides a good subject-to-lens distance. This means, first, that it is easier to light the subject, and second, that a live subject is less inclined to become overly nervous from the proximity of the apparatus.

The main idea behind designing the apparatus was that all exposures within the desired range of focus could be made at the same f-stop (f/22), and that this f-stop be as small as possible to provide the maximal depth of field. The present design of the apparatus evolved after original testing procedures for exposure and focus. The camera was set on a table, with a Wein WP 500B flash meter set at the point of focus. The position of the flash was altered to give the desired set exposure value and measurements were then taken. This procedure took into account that as bellows are extended, proportionally more light is required for proper exposure. The procedure was followed for each 10-mm extension of the bellows until the complete range of bellows extension was covered (Table 1). The optimal flash position was not consistently at one point beside the camera. It did, however, fall within a very narrow range starting with 0 mm at the film plane and extending forward to 180 mm depending on the bellows extension. It did not, fortunately, fall outside the distance from the back of the camera to the front of the fully extended bellows. This allowed a simple L-shaped bracket to be used to hold the flash. The bracket fastens to the camera (Figure 1) and the flash can be moved along the extended edge of the bracket. The bracket has been marked in millimetres to correspond to the scale on the bellows. This means that at any bellows extension a value is read on the scale and the flash moved to correspond to this value. The second, or fill-in, flash is mounted to the front of the lens with a Novoflex × shoe. Testing indicated that for this particular apparatus to give optimum color balance, an 82A filter had to be added to the lens. This was determined using a Kodak Color Separation Guide Q13 as test subject. Various filters were then tried to arrive at the closest matching results using Kodachrome 64 film. This should be repeated with each different type of color film to be used.

The complete apparatus is mounted on a "gunstock" to allow the photographer to brace the appara-

[1]Please address reprint requests to the author or to Francis R. Cook at the National Museum of Natural Sciences.

TABLE 1—Exposure values with 100-mm f/4 Bellows-Takumar lens set at f/22

Bellows extension (mm)	Magnification	Exposure factor ×	Flash setting (mm)	Camera-to-subject distance (mm)
50	0.12	1.3	180	1200
60	0.22	1.5	80	880
70	0.32	1.7	25	745
80	0.42	2.0	25	510
90	0.52	2.3	40	450
100	0.62	2.6	65	410
110	0.72	2.9	90	390
120	0.82	3.3	105	375
130	0.92	3.7	120	367
140	1.02	4.1	135	367
150	1.12	4.5	150	367
160	1.22	4.9	165	370
170	1.32	5.4	180	375

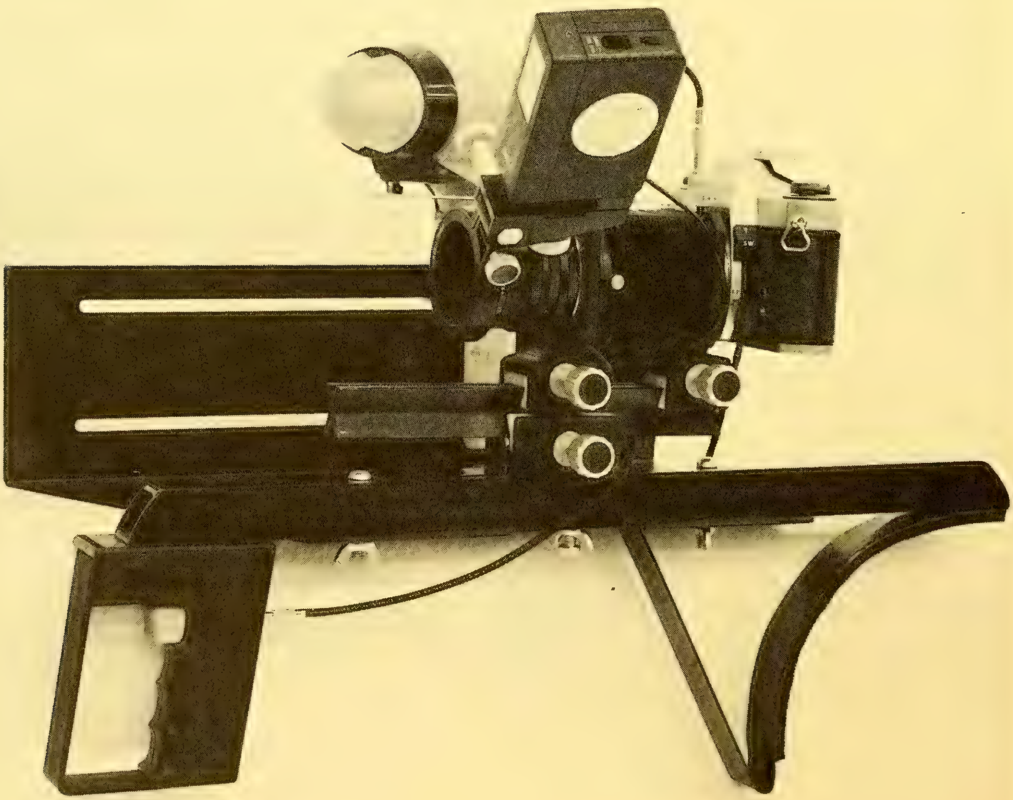

FIGURE 1. The complete close-up appartus showing the gunstock and flash arrangement. Note that the L-bracket holding the Strobonar 782 and the camera/bellows are fastened to the main gunstock by bolts and wing nuts for ease of assembly and, thus, portability.

tus against the shoulder and have the shutter release in the hand, on the grip. The camera is mounted in a manner to allow easy viewing and focusing.

Several colors of velvet are used as uniform non-reflective backgrounds. Using a consistent background such as this gives very comparable results and allows, for instance, all photographs of one species to be compared directly without having to make numerous allowances for lighting, background, etc.

For my work, additional apparati were constructed to aid in photographing live amphibians and reptiles. First, small plexiglass tanks were designed to allow photographing larval amphibians still in water (Figure 2). The tank has two narrow V-shaped compartments to hold the swimming larvae and also to restrict their movements somewhat. Behind each small compartment is an additional parallel piece of plexiglass which creates a slot to hold pieces of velvet for background. The complete tank with two compartments stands on an extended base which raises the compartments off the work surface to make it easier to approach and to photograph the specimens. This tank has allowed aquatic larvae to be photographed with the same results as adult specimens (Figure 3).

Second, to increase the maximum possible magnification, a 3× Vivitar Automatic Tele Converter has been incorporated into the system. When in use, it is mounted between the bellows and camera. With this arrangement the converter merely triples the effect of the bellows and 100-mm bellows lens, whereas if placed with the lens it alters the optics sufficiently to render the apparatus no longer effective. This means that the reproduction size can be increased to 3.96× life size. A related increase in flash settings is necessary to allow for a higher exposure value (Table 2).

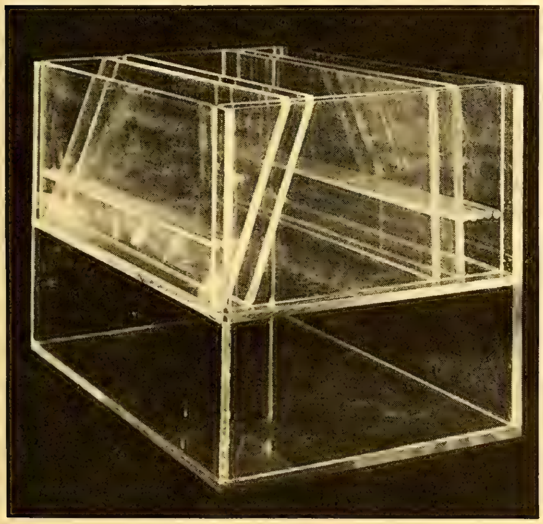

FIGURE 2. Plexiglass tank used for photographing aquatic larvae of amphibians.

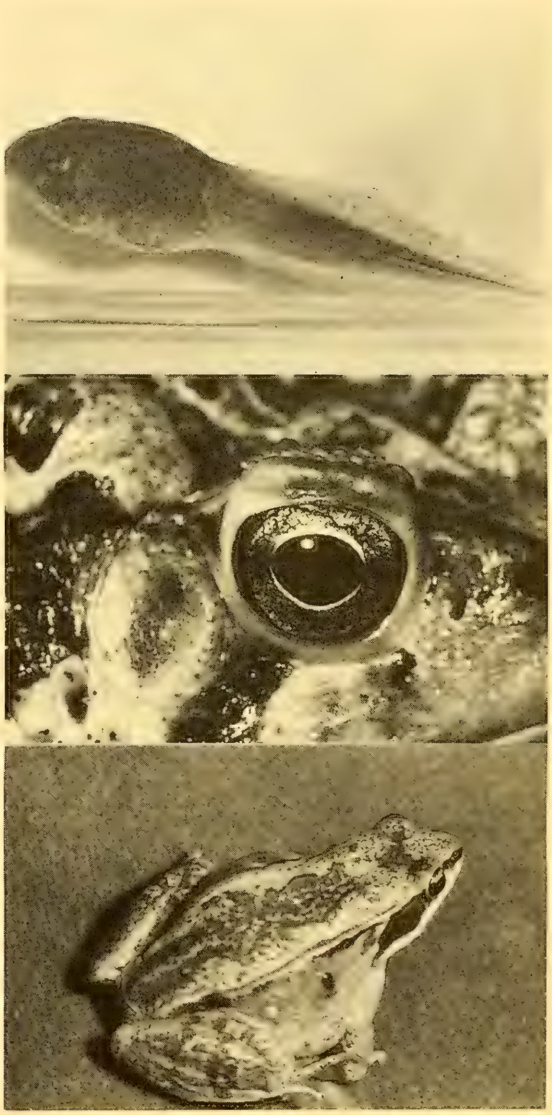

FIGURE 3. These photographs copied from original color slides, illustrate three typical types of photographs generally taken of live specimens in the Herpetology Section, National Museum of Natural Sciences. All photographs by the author. Top, *Rana catesbeiana* (Bullfrog) tadpole 0.72× life size (taken in plexiglass tank); center, *Bufo americanus* (American Toad) adult 1.32 × life size; bottom, *Rana sylvatica* (Wood Frog) adult 0.42× life size.

TABLE 2—Exposure values for 100-mm f/4 Bellows-Takumar lens set at f/22 using 3× Vivitar Automatic Tele Converter

Bellows extension (mm)	Magnification	Exposure factor ×	Flash setting (mm)	Camera-to-subject distance (mm)
80	1.26	5.0	75	510
90	1.56	5.3	100	480
100	1.86	5.6	125	460
110	2.16	5.9	150	445
120	2.46	6.3	165	435
130	2.76	6.7	180	425
140	3.06	7.1	195	425
150	3.36	7.5	210	425
160	3.66	7.9	225	430
170	3.96	8.4	245	435

The apparatus, as it now stands, can cover specimen sizes from approximately 1000 mm (0.12× life size) down to approximately 7.5 mm (3.96× life size). It is equally effective for live swimming larvae or for adults of reptiles and amphibians. Further, mark-release or other live specimens can now be photographed in the field with results as good as those for specimens photographed in the laboratory. The electronic flash operating at speeds over 1000th of a second eliminates motion blur from both the animal or the photographer; further it produces no heat, an important consideration when filming live animals.

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Food Habits of Lapland Longspurs during Spring Migration in Southern Yukon Territory

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West, G. C. and L. J. Peyton. 1980. Food habits of Lapland Longspurs during spring migration in southern Yukon Territory. Canadian Field-Naturalist 94(4): 451–454.

Lapland Longspurs (*Calcarius lapponicus*) prefer seeds of grasses and sedges to provide energy for spring migration through southern Yukon Territory. Seeds of the genera *Hordeum*, *Calamagrostis*, *Agrostis*, and *Carex* made up over 77% of the identifiable items. The standing crop of available seeds was 6587 $g \cdot ha^{-1}$ of which grasses and sedges made up 76%. Longspurs, however, selected certain species without regard to size, caloric value, or relative abundance. Each longspur requires about 12.5 g of seeds $\cdot\, d^{-1}$ for the approximately 14-d trip over some 1200 km through Yukon Territory.

Key Words: Lapland Longspur, *Calcarius lapponicus*, food habits, Yukon Territory, migration, food availability.

The visible portion of the migration of Lapland Longspurs (*Calcarius lapponicus*) to Alaska in spring follows three principal routes: a coastal route, an intermountain route, and a prairie route (West et al. 1968). All three routes intersect or parallel sections of the Alaska Highway where the birds feed along the roadsides and in occasional cleared and grass-covered areas adjacent to the road. We hypothesized that the birds ate the seemingly abundant grass seeds in proportion to their availability to acquire energy for continued migration northwestward. This report considers the foods eaten in relation to their availability along the highway and estimates the amount of seeds required by longspurs to accomplish migration through southern Yukon Territory in spring.

Materials and Methods

We collected 280 Lapland Longspurs from flocks feeding along the roadside and in fields adjacent to the road, from mile 116 to 1520 of the Alaska Highway (AH) and at Atlin, British Columbia and Haines, Alaska. Over 90% of the birds were collected between miles 630 and 1400 AH. We collected 28 specimens from seven sites in 1965, 129 from 10 sites in 1966, 76 from six sites in 1967, and 47 from 13 sites in 1968. Birds were labeled and frozen immediately. In the laboratory, gizzard and proventriculus contents were washed into petri dishes, and soft-bodied insects and insect parts were removed for immediate identification; the remainder was air dried. Identifiable seeds and grit were sorted separately from the pulverized plant and animal fragments, identified, and weighed.

In 1968, 77 0.1-m^2 samples of vegetation and ground surface were taken, mainly from the same areas in which the birds were collected. Samples were placed in paper bags and air dried, sifted to remove soil particles, and hand sorted to remove identifiable seeds and relatively inactive soil-dwelling insects. Seeds were identified by reference to the seed collection of the first author and that at the University of Alaska Herbarium. Nomenclature follows Hultén (1968).

Seeds were weighed to the nearest 0.1 mg and pooled by species for calorimetric analysis. Samples of 1 g were burned in a Parr adiabatic oxygen bomb calorimeter; those constituting only a few milligrams were burned in a Phillipson micro-bomb calorimeter.

Comparisons of the composition of diets and foods available among years and localities were made by Friedman's test of analysis of variance by ranks (Zar 1974). A probability level of $P < 0.05$ was required for hypothesis rejection.

Results

Composition of gizzard contents did not differ between sexes within years or among years ($P > 0.05$). Further statistical analysis showed no differences among six arbitrary regions along the Alaska Highway (miles 630–680; 681–800; 801–850; 851–950; 951–1050; 1051–1400). Therefore we pooled data from all 280 specimens to show the food habits of Lapland Longspurs, averaged over four springs (Table 1), during migration along about 1240 km (770 mi) of highway.

Twenty-seven types of seeds identified to species (15) or genus (12) were recorded from 280 birds, and made up 39.3% of the total gizzard contents (by dry weight). Longspurs preferred grasses and sedges over other groups of plants; the genera *Hordeum*, *Calamagrostis*, *Agrostis*, and *Carex* totalled over 77% of the identifiable items in the diet. Unknown seeds of two types made up 1.6% and larvae, pupae, and adult insects made up only 0.4%. Fragmented material, judged to be over 90% plant matter, made up 60.3% of the total gizzard contents (Table 1). The average total dry weight (± 1 SD) of seeds, insects, and fragmented material in the gizzards of the 280 longspurs was 0.097 ± 0.047 g. Not included in this total was an average of 0.116 ± 0.053 g of grit. A linear regression analysis of the total amount of seeds, insects, and

TABLE 1—Seeds eaten by Lapland Longspurs, seeds available, and caloric equivalents of seeds along the Alaska Highway

Species	Gizzard contents (modified)[1] % dry wt.	Standing crop % dry wt.[2]	Caloric equivalent[3] $cal \cdot g^{-1} \pm 1$ SD(n) ash-free dry wt.	
Picea glauca	—	0.9	5859	(1)
Agrostis scabra	8.5	13.3	4707 ± 69	(6)
Calamagrostis canadensis	9.0	19.8	4857 ± 161	(5)
Festuca altaica	0.2	4.6	4549 ± 143	(3)
F. brachyphylla	—	0.3	4969	(1)
Bromus inermis	2.6	6.3	4394 ± 45	(3)
Agropyron sp.	—	3.8	4407 ± 1	(2)
Hordeum jubatum	39.5	13.9	4450 ± 220	(12)
Carex praticola	—	12.9	5170 ± 12	(3)
C. aquatilis	4.8	0.3	5140 ± 118	(5)
C. atrata	0.9	0.3	5089	(1)
Carex spp.	14.8	0.6	4709 ± 122	(5)
Luzula sp.	0.2	—	—	
Betula papyrifera	0.1	—	5637 ± 49	(5)
Alnus incana	0.5	—	3698	(1)
Chenopodium album	0.4	1.9	4722 ± 177	(5)
Stellaria sp.	5.2	0.6	5463	(1)
Arenaria sp.	1.1	0.2	4619 ± 115	(3)
Ranunculus sceleratus	0.8	—	5299 ± 392	(2)
Corydalis aurea	—	4.0	4677 ± 84	(3)
Potentilla sp.	2.2	11.5	5400 ± 62	(5)
Oxytropis campestris	—	2.2	4802 ± 147	(4)
Geranium sp.	—	0.1	—	
Viola sp.	t	—	—	
Cornus canadensis	t	—	—	
Empetrum nigrum	0.7	—	4848 ± 16	(2)
Arctostaphylos uva-ursi	3.2	—	5278 ± 27	(2)
Androsace sp.	0.1	—	—	
Polemonium sp.	—	0.2	—	
Myosotis alpestris	t	—	—	
Labiatae	—	0.6	—	
Taraxacum sp.	0.2	—	5105[4]	(3)
Compositae	—	0.5	—	
Unknown seeds	4.1	0.2	—	
Insecta	0.9	0.1	5528 ± 152	(3)
Fragmented matter	—	—	5333 ± 172	(10)

[1]Percentage recalculated after eliminating fragmented matter which made up 60.3% of the total gizzard contents.
[2]The total standing crop was $6567 \ g \cdot ha^{-1}$.
[3]1 cal = 4.1868J.
[4]From Kendeigh and West 1965.

fragmented material versus time of day of collection yielded a significant positive slope showing that there is an increase of 3.6 mg of gizzard contents per hour of the day from 07:00 to 20:00.

The samples of seeds collected from ground surface and overlying vegetation samples also did not differ among the same six arbitrary sections of the AH. All samples were collected in 1968. The standing crop of seeds available in spring on the sample plots consisted of 22 varieties of seeds identifiable to species (13), genus (7), and family (2) (Table 1). There were four unidentified seed types which made up only 0.2% of the total standing crop of $6567 \ g \cdot ha^{-1}$. Grasses and sedges made up 76% of the total standing crop of available seeds while the ground-dwelling insects made up only 0.1%.

Caloric equivalents of the most abundant seed species, the insects found in gizzards, and samples of the fragmented gizzard material ranged from 3.7 to $5.9 \ kcal \cdot g^{-1}$ (where 1 cal = 4.1868J) ash-free dry weight (Table 1). The caloric equivalent of identifiable insects in proventricular and gizzard contents was $5.5 \ kcal \cdot g^{-1}$ ash-free dry weight, and the fragmented material averaged $5.3 \ kcal \cdot g^{-1}$, higher than would be expected from the preponderance of remains of seeds in that material.

Discussion

We are unaware of other studies of food habits of spring migrant fringillids in northwestern North America. Gabrielson (1924) reported on an examination of 656 stomachs of Lapland Longspurs collected throughout the year. Unfortunately, he divided his analysis into summer (June through September) and winter (October through May) seasons and did not report the analysis of spring migrating birds separately. We could not determine where Gabrielson's May samples were taken but he stated that sedges made up over 10% of the food from all birds, represented chiefly in samples collected in Northwest Territories, Ontario, and Montana in "winter." Probably the Northwest Territories samples were taken in spring.

No spring plant growth has taken place at the time longspurs are migrating into Alaska. "Winter" foods reported by Gabrielson (1924) included only 4% of animal origin (mostly in April by four individuals). Of the remaining 96%, 61.7% was grass seeds, 10.3% sedges, and the balance included *Portulaca, Chenopodium, Amaranthus*, and *Ambrosia*. Our data also show grasses and sedges predominating (grasses 59.7%, sedges 20.6%) with 14 species of seeds and insects making up the remainder (19.7%). Although the majority of Gabrielson's (1924) birds were collected in the midwestern United States, the preference

for grasses and sedges persists into southern Yukon Territory during migration.

Longspurs preferred seeds of *Hordeum jubatum* and apparently also selected seeds of *Stellaria, Arenaria*, and *Arctostaphylos* out of proportion to their availability (Figure 1). They took sedge seeds (*Carex*) roughly in proportion to their collective availability (Figure 1) although they ignored some species (e.g., *C. praticola*) which were abundant and selected others (e.g., *C. aquatilis*) (Table 1). The utilization of *Calamagrostis, Agrostis,* and *Chenopodium* was somewhat less than their relative availability. *Bromus, Potentilla*, and *Festuca* were little utilized in relation to their availability while a number of other prominent species such as *Brassica* and *Agropyron* were not eaten at all (Figure 1, Table 1). From the small but noticeable amounts of *Arctostaphylos* and *Empetrum* (also *Cornus*) found in the gizzards but not in the ground samples (taken in open areas), longspurs evidently fed also along the margins of woods where these plant species are more likely to occur. Alternatively, they may have acquired seeds of the two ericaceous species in snow-free alpine areas as they entered Yukon Territory and Alaska over mountain passes (routes 1 and 2 of West et al. 1968).

The total amount of food in the gizzards increased slowly through the day and reached a peak at our last collecting time near 20:00. The mean weight difference between the 07:00 samples and the 20:00 samples was 46.8 mg. If we assume that longspurs were feeding at 06:00 and went to roost at 20:30, however, the gain would amount to 52.2 mg, a small amount but representing over 50% of the average total gizzard contents (less grit). From the energy requirements noted in a later section, the daily intake of food must be over 100 times the average gizzard content. The increase in weight is then only an indication of either increasing food intake with time of day or the jamming up of the digestion and assimilation process owing to the high food intake as the day progresses.

A more pronounced increase in gizzard content weight was observed by Dolnik and Blyumental (1967) for fall migrating Chaffinches (*Fringilla coelebs*) on the Baltic Sea coast. They measured increases from a morning low of about 100 mg to an evening peak of about 350 mg, which is a 3.5× increase compared with only a 1.7× increase in the longspurs.

The rate of breakdown of seeds and especially insects in the gizzard of migrating birds must be extremely rapid to permit the required processing of foods (Custer and Pitelka 1975). Although these birds must store energy for overnight survival, they are ingesting food much more rapidly than necessary to supply only that level of sustenance. Unlike Willow

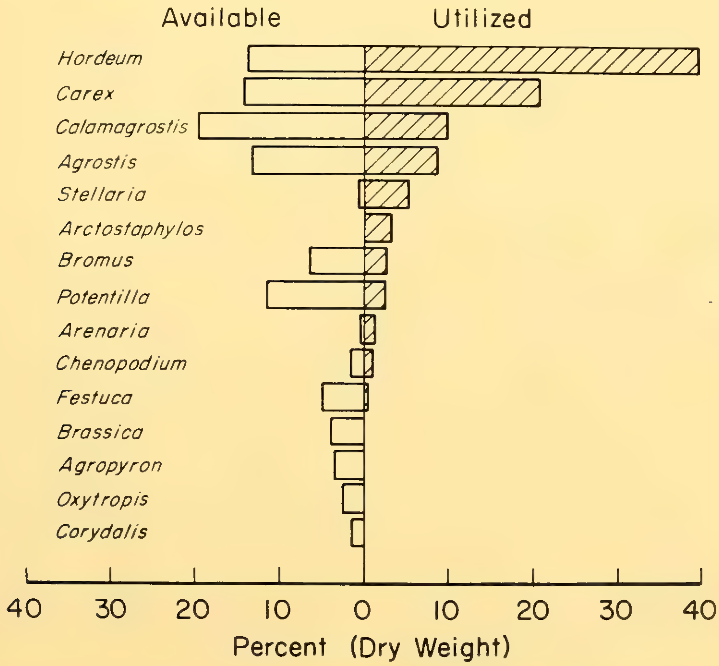

FIGURE 1. Utilization of seeds by migrating Lapland Longspurs in relation to their availability.

Ptarmigan (*Lagopus lagopus*), which also shows a marked increase in crop contents with time of day to provide overnight and emergency survival reserves for arctic winters (Irving et al. 1967), the longspurs are eating to deposit fat for the next leg of their migratory flight (West et al. 1968).

Caloric equivalents were determined for 98.2% of the diet of migrating Lapland Longspurs (Table 1). The average caloric value was 5095 $cal \cdot g^{-1}$ ash-free dry weight of seeds eaten. Selection was not generally proportional to availability by weight of seeds present. We measured the length and width of the dominant seeds eaten by, and available to, migrating longspurs. Five types of seeds preferentially selected by longspurs had an average length of 1.53 ± 1.43 mm and width of 1.02 ± 0.53 mm while 10 types not preferentially selected had an average length of 2.64 ± 2.18 mm and width of 1.12 ± 0.50 mm. The differences are not statistically significant. The mean caloric value of the five preferred types was 4990 ± 436 $cal \cdot g^{-1}$ and of the 10 not selected 4769 ± 317 $cal \cdot g^{-1}$. Again the difference is not statistically significant.

We do not have data on nutrient quality or husking time, although of the five species of preferred seeds, only *Hordeum* requires husking. Ripe *Carex* seeds are relatively easy to extract, *Arenaria* and *Stellaria* are in capsules, and *Arctostaphylos* may be consumed as dried berries. In contrast, of the 10 species not selected, the five grasses must be husked. Selection is probably influenced by size of seed (smaller preferred), efficiency of energy acquisition (a combination of rapid husking time and ease of location, e.g., many together in a capsule or seed head), but probably not discernibly by caloric content nor protein, fat, or soluble carbohydrate content (Willson 1971).

Longspurs require a substantial amount of energy to accomplish their northward migration. Estimates of the energy cost of existence at 0° C gives 25.3 $kcal \cdot bird^{-1} \cdot d^{-1}$ for a 28-g longspur (Kendeigh et al. 1977, formula 5.29) and the additional cost of free-living is estimated at 1.8 $kcal \cdot bird^{-1} \cdot d^{-1}$ (Kendeigh et al. 1977, p. 203). Temperatures in southern Yukon Territory are near freezing at night during early May but warm to +10° C or so during the day. Therefore, the energy cost for the average day might be no more than 25 kcal.

The caloric equivalent of the diet is 5095 calories. The efficiency of digestion of seeds is estimated to be about 75% (Kendeigh et al. 1977, p. 193); therefore, the caloric equivalent available to the bird from food consumed would be about 3820 $cal \cdot g^{-1}$. The 25 kcal required for maintenance and free-living, therefore, would require the intake of 6.5 g of dry seeds.

The energy expenditure for migration, which includes the cost of fat deposition as well as of migratory flight, is estimated at 0.25 $kcal \cdot km^{-1}$ (Kendeigh et al. 1977, formula 5.48). The 1240 km (770 mi) of AH that we surveyed would cost an individual longspur 310 kcal. Irving (1961) calculated the rate of movement of longspurs into Alaska as averaging about 88 $km \cdot d^{-1}$. The 1240 km thus would take about 14 d and require about 22 $kcal \cdot d^{-1}$, which is equal to about 6 g of seeds per day. Therefore, a longspur requires about 6.5 g of seed for maintenance and 6 g for migration or a total of 12.5 g of seeds per day during their migration through southern Yukon Territory.

Acknowledgments

Armi C. Salo carefully sorted and aided in the identification of seeds, and with the help of Marilyn Modafferi performed the caloric analyses. Charles Gunn of the United States Department of Agriculture identified a few seeds which we could not determine. Samuel Harbo advised on statistical techniques. We appreciate the critical manuscript review of Gerald F. Shields. This research was supported in part by grant GM 10402 from the National Institute of General Medical Sciences.

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Notes

Occurrence of *Myotis californicus* at Revelstoke and a Second Record of *Myotis septentrionalis* for British Columbia

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van Zyll de Jong, C. G., M. B. Fenton, and J. G. Woods. 1980. Occurrence of *Myotis californicus* at Revelstoke and a second record of *Myotis septentrionalis* for British Columbia. Canadian Field-Naturalist 94(4): 455–456.

Several *Myotis californicus* and a single *Myotis septentrionalis* were captured near Revelstoke, British Columbia, thus extending their known ranges.

Key Words: California Bat, *Myotis californicus*, Northern Long-eared Bat, *Myotis septentrionalis*, British Columbia, new records.

In the Revelstoke area British Columbia, we captured several California Bats (*Myotis californicus*) and a single Northern Long-eared Bat (*Myotis septentrionalis*), which extends the known range for both species in British Columbia.

Myotis californicus was captured repeatedly at lower elevations (< 600 m) and appears to be common in the area around Revelstoke. One bat was collected on 18 June and preserved as a specimen in the National Museum of Natural Sciences (NMC 44952). The previous and nearest known records for this species are from Hemp Creek, 51°50′N, 120°05′W (Cowan and Guiguet 1965), approximately 150 km NW of Revelstoke and from Castlegar and Nelson (specimens in NMC), approximately 200 km S of the present site. It is possible that *M. californicus* is common and widely distributed throughout the valley of the Columbia River and its tributaries.

Of even greater interest was the collection of a single adult female *M. septentrionalis* (NMC 44951) on 18 June; this appears to be only the second record of this species for British Columbia. The previous record is a specimen in the United States National Museum (USNM 256557) collected approximately 600 km N of the present locality at Hudson Hope, on 14 September 1931. This specimen was originally identified as *Myotis k. keenii* (van Zyll de Jong 1979). The nearest locality is near Cadomin, Alberta approximately 236 km NNE of Revelstoke. Other records from Alberta and the Northwest Territories have been reported (van Zyll de Jong 1979). Revelstoke is in an intermediate geographic position between the ranges of *M. keenii* and *M. septentrionalis;* thus this specimen is of considerable taxonomic interest.

It was one of several bats flying over a pool along the Giant Cedars Trail in Mount Revelstoke National Park. This site is 1 km W of Woolsey Creek near the east boundary of the park and is situated in the Columbia Forest Region (Rowe 1972) at an altitude of 700 m. *Myotis septentrionalis* emerged around 21:30 and appeared to feed and drink over a small pool less than 1 m in diameter and along a trickle of water leading into and out of the pool. Using the apparatus described elsewhere (Fenton et al. 1980) the species was found not to be active over a torrential creek 10 m from the small pool or over the forest floor. The specimen was taken with a hand net during one of its passes over the pool.

The initial identification of this bat was subsequently confirmed on the basis of cranial measurements (van Zyll de Jong 1979) with discriminant scores for the first and second discriminant axes of 8.04 and −30.32, respectively. These scores place the specimen in the center of the *M. septentrionalis* cluster. There is thus no evidence of intermediacy between *keenii* and *septentrionalis* in either external or cranial characters. External measurements (in millimetres) and weight of the specimen were as follows FA 40, TL 86, T 41, HF 8, E 18, tragus 10, body weight 5.3 g. The specimen was pregnant with one embryo (crown–rump length 6 mm) and was collected under a federal permit to J. G. Woods.

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An Aggregation of Gravid Snakes in the Quebec Laurentians

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Gordon, David M. and Francis R. Cook. 1980. An aggregation of gravid snakes in the Quebec Laurentians. Canadian Field-Naturalist 94(4): 456–457.

An embankment composed mainly of rocks and sand at Huberdeau, Argenteuil County, Quebec, was apparently utilized as a communal nesting site by adult female Smooth Green Snakes, *Opheodrys vernalis*, and as an aggregation site by gravid female Redbelly Snakes, *Storeria occipitomaculata*. Both adult and juvenile Common Garter Snakes, *Thamnophis sirtalis*, of both sexes were also present in contrast to the all-female representation of the other species.

Key Words: Laurentian area, Quebec, Smooth Green Snake, *Opheodrys vernalis*, Redbelly Snake, *Storeria occipitomaculata*, communal nesting, aggregation site.

Aggregation of gravid snakes prior to communal nesting has been reported for many species of oviparous snakes. Communal nesting has been documented for two Canadian species, the Northern Ringneck Snake, *Diadophis punctatus edwardsi* (Blanchard 1937; Gilhen 1970), and for the Smooth Green Snake, *Opheodrys vernalis* (Cook 1964; Fowler 1966) and was discussed by Gregory (1975). Aggregations of gravid individuals of the live-bearing species are less frequently documented. Finneran (1953) and Fitch (1960) reported on aggregations of gravid female Copperheads, *Agkistrodon contortrix*. Gregory (1975) noted several aggregations of gravid individuals of the Red-sided Garter Snake, *Thamnophis sirtalis parietalis*, and the Redbelly Snake, *Storeria occipitomaculata*, and speculated that they could be due to the limited number of sites providing both optimum temperatures for development of embryos and shelter from predators.

During the course of fieldwork for the National Museum of Natural Sciences in 1975, Gordon observed what appeared to be an instance of communal nesting by the Smooth Green Snake, and an aggregation of gravid Redbelly Snakes. These observations were made at Huberdeau, Argenteuil County, Quebec (46° 59′N, 74° 38′W). The site is at an elevation of approximately 190 m and the area lies within the Great Lakes – St. Lawrence forest region.

Observations and Discussion

The collection site lay alongside a slightly elevated roadbed (0.5–1.0 m) and was bordered by a clearing containing scattered clumps of bushes. The roadbed, widened 2–10 m by the dumping of additional fill, formed a bank approximately 100 m long. The fill consisted mostly of rocks mixed with sand. The rocks were generally rounded and varied in size from 2 to 20 cm. This mixture is the same as the soil found in the vicinity. Boards and branches of cut brush were occasionally mixed with the fill. The bank faced west and varied in slope from approximately 45° to nearly perpendicular.

The bank was divided into three zones based on the size and number of passages and spaces. Zone 1 consisted of the larger rocks which lay at the bottom of the slope and had little or no sand between them, thus allowing large spaces and numerous passages. Zone 2 overlaid zone 1 and extended to the top of the slope; it contained slightly smaller rocks surrounded by sand,

with numerous passages and spaces between them, probably caused by run-off erosion. Zone 3 lay behind zone 2, toward the interior and also extended to the top of the slope, and was composed of rocks of mixed sizes and surrounded by packed sand. The passages and spaces that occurred in zone 3 were mostly along branches and boards which were buried in the bank. The soil in this zone was moist and warm to the touch even in the late evening.

All collections were made been 17:30 and 21:00. All specimens are catalogued in the National Museum of Natural Sciences collection. The first indication that snakes were using the bank as a refuge came from the large number of shed skins intertwined amongst the rocks at the base of the slope. Different areas of the bank were dug out every night. Ground-cover, rocks and boards, west of the bank was also sampled to a maximum distance of about 150 m.

Different species and sizes of snakes were found in the three sections of the bank. Large adult Eastern Garter Snakes, *Thamnophis s. sirtalis*, were found in zone 1, juvenile garter snakes and Redbelly Snakes in zone 2, and Smooth Green Snakes in zone 3.

The possibility of a communal nesting site for Smooth Green Snakes was indicated when two old egg clutches were discovered. The clutches were about 15 cm apart and contained four and six eggs respectively. Eight gravid females and one non-gravid female were taken from the bank (three on 24 June and two each on 25, 26, and 30 June). The clutch sizes for these specimens (determined by dissection) were: three specimens with 6 eggs each, three with 7 eggs each, and one each with 9 and 10 eggs, for a mean clutch of 7.25 eggs. On 24 July 1975, a clutch of 10 eggs was taken from the bank. It is not known whether this clutch represents the eggs of one or more individuals. The two old clutches and the new clutch were all taken from zone 3. No male Smooth Green Snakes were taken from the bank, although seven were taken from beneath ground-cover adjacent to the bank site (one on 24 June, two on 26 June, four on 30 June). No juveniles were collected or sighted in the area.

An aggregation of gravid Redbelly Snakes also seems to be indicated. Nine gravid females and one juvenile female were taken from the bank (two each on 24 and 30 June and 1 July; four on 26 June). No males were collected from the bank, and only two were taken from the surrounding area (one each on 25 June and 1 July).

The situation for Eastern Garter Snakes is not as clear. Adults and juveniles of both sexes were taken from the bank; however, gravid females were more commonly taken from the bank than from the surrounding area. The greater number of gravid females at the bank site can be explained in the context of available ground-cover. Most of the ground-cover in the bank consisted of rocks which were well set in the soil and did not offer enough space for gravid females (which are generally larger than adult males). When suitable ground-cover (mostly boards) was examined, gravid females were found.

The total absence of male Smooth Green Snakes and Redbelly Snakes from the bank site is perplexing. Even accepting the premise of an "aggregative drive" amongst the females of these species does not explain the lack of males in what appears to be suitable cover in all respects. In the case of the Redbelly Snake, the times during which the collections were made may have been a factor in males not being found in the bank area. It is possible that the males stay active later in the evening. Perhaps the gravid females must meet certain thermal requirements that are not imposed on the males. As a result, the gravid females take refuge in the bank and escape the cool evening temperatures which are prevalent in the Laurentian Mountains. This would also explain the disproportionate ratio of the sexes (10 ♀, 2 ♂), females from the bank and males from the area surrounding the bank. As snakes were only searched for under ground-cover, the active males would not be found. The preceding explanation does not seem to hold for Smooth Green Snakes as an approximately equal number of both sexes were collected (9 ♀, 7 ♂).

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Perukes in Wild Moose

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A male Moose from Alberta with female features is described. The grotesque velvet antlers are compared with two sets of similar antlers reported from eastern Canada. The cause of the abnormal antlers may have been testicular atrophy or accidental castration.

Key Words: Moose, *Alces alces*, perukes, antlers, testicular atrophy, castration.

Abnormal antler conformation and retention of velvet in male cervids are usually associated with testicular atrophy or castration. Testicular atrophy and related velvet antlers have been described in various species of *Odocoileus,* namely White-tailed Deer (*O. virginianus texanus*) in Texas (Taylor et al. 1964), Mule Deer (*O. hemionus hemionus*) in Colorado (Murphy and Clugston 1971), and Black-tailed Deer (*O. h. columbianus*) in California (De Martini and Connolly 1975). Similarly, castration and the effects upon antler growth have been observed in a variety of deer species. If an adult deer is castrated in the fall or after the velvet has been shed, its bony antlers are lost within several weeks and replaced by new ones that are retained permanently in velvet. Administering testosterone can induce the velvet to peel off and the antlers to shed (Wislocki et al. 1947). Without testosterone or estrogen, "castrate antlers" will continue to undergo annual increments of growth, and may eventually develop into very grotesque head pieces, or "perukes" (Goss 1968).

Grotesque antlers in wild Moose (*Alces alces*) have been reported previously in Canada by Seton (1929) and Dickie (1960). The Moose reported by Seton (1929) was taken near the upper Ottawa River in 1897. He stated: "The horns were porous and spongy; probably the animal had been emasculated." The antlers are in the Royal Ontario Museum in Toronto (A. B. Bubinek, Ontario Ministry of Natural Resources, personal communication). The Moose reported by Dickie (1960) was shot by an Indian in the early 1900s near Roberts in northern Ontario. Dickie (1960) noted the antlers "resembled a coral bunch" and were light in weight for their size. He stated: "One conjecture is that the bull had suffered injury in battle or otherwise to the reproductive organs." The article refers to the unusual Moose as a "windigo" (Wee-tee-go in Cree is the evil spirit that devours mankind; see Hopwood 1971). The report goes on to state "The sight of any malformation in an animal has always been regarded as an omen that bodes ill for the Indian viewer. . . . It is not without significance that the superstitions of the older tribesmen were seemingly justified as the hunter who killed the windigo Moose died violently shortly after when run over by a train." The antlers are presently in the possession of V. F. J. Crichton, Department of Mines, Natural Resources and Environment, Winnipeg, Manitoba.

I have investigated one case of apparent testicular atrophy or accidental castration in wild Moose. In February 1975 near Lake Wabasca in northern Alberta, an Indian shot an adult male Moose with a set of unusual antlers in velvet (Figure 1). The animal was unusually fat for a bull Moose at that time of year and the Indian referred to the animal as a "steer" because of the undeveloped testes. I had an opportunity to examine only the head of this Moose, so the presence or absence of any testicular tissue was never established. The older Indians from that region were familiar with "steer-like" Moose, because they had seen velvet antlers on Moose that were retained year round (D. Cardinal, Wabasca, Alberta, personal communication). The antlers from the Wabasca Moose were very similar in appearance to photos of the set from Ontario. The antlers were very nodular, covered with mostly hairless skin and were poorly calcified. The facial coloration of the head of the Alberta Moose was almost completely brown and it had the characteristic brown snout of a female Moose as described by Mitchell (1970).

Bubenik et al. (1977) suggest that in male Moose the skin of the head is a target tissue for testosterone and related androgens. In such cases, the testosterone will stimulate melanin synthesis from tyrosine and the skin and hair will become progressively darker, grading into black (Wilson et al. 1973; Wilson and Spaziani 1976). The fact that facial coloration is sex dimorphic, even in 6-mo-old calves (Bubenik et al. 1977), suggests that the testes of the Alberta specimen were gone or the testosterone-producing elements of the testes were completely atrophied.

The abnormal velvet antlers, undeveloped testes, female head features, and winter fat condition of the Alberta Moose are in agreement with the descriptions

FIGURE 1. Male Moose skull with a peruke.

of the effects of both hypogonadism and castration in other cervids (Taylor et al. 1964; Murphy and Clugston 1971; De Martini and Connolly 1975). Toxic substances have been suggested as the cause of testicular atrophy (Thomas et al. 1964; De Martini and Connolly 1975), but to my knowledge these suggestions have not been confirmed. Accidental castration may have occurred in the cases of the Moose described.

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Range Extension for the Yellow-spotted Salamander, *Ambystoma maculatum*, in Quebec

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Gordon, David M. and Francis R. Cook. 1980. Range extension for the Yellow-spotted Salamander, *Ambystoma maculatum*, in Quebec. Canadian Field-Naturalist 94(4): 460.

A northern extension of approximately 400 km from the previously known range is reported for Yellow-spotted Salamanders, *Ambystoma maculatum*, in Quebec.

Key Words: Yellow-spotted Salamander, distribution, Quebec, *Ambystoma maculatum*.

The exact northern distribution of Canadian amphibian species is poorly known. The geographic extent and lack of road access to many areas are factors contributing to our paucity of information. The short spring breeding season of the Yellow-spotted Salamander (or Spotted Salamander), *Ambystoma maculatum*, and the fact that it is rarely encountered outside of the breeding season cause even more difficulties in gathering information on the distribution of this species.

During the course of a field survey of central Quebec conducted for the National Museums of Canada in 1975 (by DMG) specimens of the Yellow-spotted Salamander were collected on 6 June 1975 about 20 km N of Chibougamau, Quebec (approximately 49° 54′N, 75° 15′W) (Figure 1). This is in boreal forest dominated by Black Spruce (*Picea mariana*).

Two specimens were collected from underneath separate rocks, which were lying on the side of a small but steep bank of a hillock composed of unsorted rock and earth. Other than rocks, fallen spruce trees in various stages of decomposition provided potential cover. A light drizzle had been falling for over 24 h on the day the collection was made and probably caused the salamanders to move toward the surface. On the same day, 39 juvenile Blue-spotted Salamanders, *Ambystoma laterale* (National Museums of Canada Catalogue Number 17142), were taken under rocks, and ranged in total length from 60 to 109 mm (snout to anterior margin of vent 36 to 57.5 mm).

Both *A. maculatum* specimens (National Museums of Canada Catalogue Number 17141) were juvenile males, with total lengths of 98 and 109.5 mm and body lengths (snout to anterior margin of vent) of 50 and 55 mm respectively.

This record represents an extension of approximately 400 km north at the range limit depicted by Conant (1975). The locality is also well north of the boundary of Herpetofaunal Region 4 postulated as the northern limit for this species by Bleakney (1958, p. 24).

FIGURE 1. The distribution of the Yellow-spotted Salamander, *Ambystoma maculatum*, in Quebec and Ontario. The shaded area represents the range according to Conant (1975). The broken line is the northern limit as suggested by Bleakney (1958). The solid circles are records based on National Museum of Natural Sciences specimens. The star symbol indicates the new locality near Chibougamau, Quebec (49° 54′N, 74° 15′W).

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Overland Travel by Canada Goose Broods

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Giroux, Jean-François. 1980. Overland travel by Canada Goose broods. Canadian Field-Naturalist 94(4): 461–462.

I observed two Canada Goose (*Branta canadensis*) broods that moved at least 8.3 km overland at an average speed of 2.3 km/h. The geese followed a roadside and a fenceline, adding approximately 2.3 km to the distance travelled. Such behavior may help to reduce predation.

Key Words: Canada Goose, *Branta canadensis*, brood, movement, predator, prairie, Alberta.

Broods of Canada Geese move variable distances from nest sites to the brood-rearing areas. Movements of 6–8 km through marshes and along rivers have been reported (Dow 1943; Culbertson et al. 1971) as well as combined travel of 8–16 km over water and land (Geis 1956; Hanson 1965). Geis (1956) reported overland journeys of up to 1.6 km. During a study of waterfowl near Brooks, Alberta (Giroux 1979), I witnessed an overland journey by Canada Goose broods between two impoundments (E and H) located 5.5 km apart.

At 16:30 on 22 May 1978, I saw two groups of goslings walking a few metres apart across the prairie in a northeast direction. Each group was escorted by two adults. The geese were about 1.4 km from impoundment E where 10 goose clutches were known to have hatched during the preceding 2 wk. I watched the geese with a spotting scope (25×) from a vehicle at a minimum distance of 0.6 km, which did not appear to disturb them. Geese walked or ran, and stopped for a few minutes on several occasions. Travel was not in a straight line between the two impoundments, as the geese turned twice at right angles to follow a roadside and a fenceline. This route added approximately 1 h and 2.3 km of travel compared to a straight-line route.

Observations lasted for 3 h until the birds arrived on the shores of the second impoundment (H). At that time, I noted that one pair of adults had eight goslings, four about 5 d old and four about 10 d old. The second pair was followed by 14 goslings of several different ages but all less than 2 wk old. Therefore, brood crèching must have occurred.

While the geese were under observation, they travelled a distance of 6.9 km at an average speed of 2.3 km/h. With the additional 1.4 km that they presumably travelled before observation started, those goose broods moved at least 8.3 km overland.

Impoundment E is a shallow basin where water levels decline throughout the summer, and no broods were seen there after the first week of June during the 3 yr of my study (Giroux 1979). Impoundment H has a more permanent water supply and broods were observed there throughout the summer. Geese nesting at impoundment E commonly move to impoundment H during the 2 or 3 wk following the hatching peak around 15 May. Glasgow (1977) also reported that broods of Canada Geese on his study area moved away when the young were less than 2 wk old.

Adult geese may have used the road and the fence as landmarks for orientation. The presence of the fence may have discouraged avian predators from attacking the broods, and taller vegetation along the roadside ditch provided cover for the birds against mammalian predators. Glasgow (1977) saw a Coyote (*Canis latrans*) intercept a goose brood moving between two lakes, and kill several goslings. If detours to follow fences or roadside ditches reduce predation on broods during overland travel, that advantage may well outweigh the extra time spent.

Crèching behavior (two pairs with 22 goslings) was unexpected, because Glasgow (1977) had suggested that predation pressure should favor small inconspicuous groups for overland movement in these very open habitats. Sherwood (1967) indicated that older, more experienced, and dominant pairs usually lead such crèches. It may be advantageous to have many goslings escorted by those few pairs that are most familiar with the area. This would also reduce the number of conspicuous adults accompanying the young across the bald prairie.

This observation was made when I was employed by Ducks Unlimited (Canada). The University of Alberta also provided logistic support. I am grateful to D. Boag and P. Herzog for their comments on the manuscript and to N. Foy for field assistance.

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Feeding of Nestling Cliff Swallows by a House Sparrow

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Hofman, D. Edward. 1980. Feeding of nestling Cliff Swallows by a House Sparrow. Canadian Field-Naturalist 94(4): 462.

Four feedings of nestling Cliff Swallows by a presumed female House Sparrow were observed between 14:00 and 17:00 on 15 July 1979. Feedings by the sparrow occurred at intervals of 45 min, while the swallow parents fed every 7–9 min during the same period.

Key Words: Cliff Swallows, *Petrochelidon pyrrhonota*, feeding, House Sparrow, *Passer domesticus*, interspecific, nestlings.

In May 1979, 25 Cliff Swallow (*Petrochelidon pyrrhonota*) nests were built under the eaves of a building at the Brooks Wildlife Centre, Brooks, Alberta. At the opposite end of the building a pair of House Sparrows (*Passer domesticus*) constructed a nest inside an old Cliff Swallow nest, the opening of which they had widened. By June, egg-shells on the ground below the sparrow nest suggested that the clutch had hatched successfully. Egg-shells were also found below the swallow nests, and young were later observed in the nest openings. On 15 July, I saw a female-plumaged House Sparrow perched at the opening of a Cliff Swallow nest in which young were visible. Approximately 45 min later, I again observed a female sparrow on the roof of the building about 1 m from the same nest. The sparrow had what appeared to be a small moth in its bill. Moments later the sparrow perched at the opening of the nest and a nestling swallow opened its bill to receive the food. Thereafter, I observed 3 more feedings at the same nest by the sparrow, as well as 20 or more feedings by the swallows, between 14:45 and 17:00. In each case, an adult bird perched at the opening to the nest, and inserted food (small insects) directly into the gaping mouth of the nearest young swallow. No interactions were observed between adult swallows and the sparrow; however, in every case the sparrow waited until the swallows had fed and left before it fed the young. I was unable to learn of other observations of interspecific feeding involving these two species.

Welty (1975. The life of birds. W. B. Saunders Company, Philadelphia. 623 pp.) suggests that displacement feeding activity results "from loss of their own young coupled with strong momentum from the feeding instinct." The House Sparrow which I observed feeding the nestling swallows approached each time by an identical route, landing in turn on a nearby fence, an electrical cable leading to the building, on the eave, and finally, after a cautious approach on foot, at the nest. Such behavior suggests that this was an adult bird accustomed to exercising care around its own nest, rather than an inquisitive juvenile. I cannot confirm that this sparrow was the same that earlier constructed the nearby sparrow nest, although no others were found, and I never saw nestlings in the sparrow nest. Whether or not the sparrow watched on 15 July had lost its own brood, it seems clear that the behavior described was a directed feeding effort and not merely a mistake, and it may most easily be explained as a displacement activity.

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First Breeding Record of Black-crowned Night Heron in Nova Scotia

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Quinney, T. E. and P. C. Smith. 1980. First breeding record of Black-crowned Night Heron in Nova Scotia. Canadian Field-Naturalist 94(4): 463.

Three Black-crowned Night Heron (*Nycticorax nycticorax*) nests found on Bon Portage Island, Nova Scotia, in June 1977, provide the first breeding record for this species in Nova Scotia. Nest contents and timing of reproductive events are described.

Key Words: Black-crowned Night Heron, *Nycticorax nycticorax*, Bon Portage Island, Nova Scotia, breeding, new records.

The Black-crowned Night Heron (*Nycticorax nycticorax*) has an extensive breeding range in North America (Palmer 1962, p. 447). This includes all states along the Atlantic seaboard with the exception of New Hampshire (Custer and Osborn 1977), as well as New Brunswick (Godfrey 1966, p. 40), but no record was known for Nova Scotia (Tufts 1973, p. 64).

While censusing a Great Blue Heron (*Ardea herodias*) colony on Bon Portage Island (45°30′N, 65°45′W), Shelburne County, Nova Scotia, on 1 June 1977, we discovered three active Black-crowned Night Heron nests among the 50 occupied Great Blue Heron nests. Two adult Night Herons were seen briefly overhead while the nests were being examined. In July 1976, a juvenile and an adult had been seen in the vicinity of the Blue Heron colony but no nests were located.

The three nests were located 4–5 m above ground in Balsam Firs (*Abies balsamea*). All consisted of coarse twigs with a lining of finer twigs. Nest cups were very shallow. The nests contained three eggs, one egg plus three nestlings, and four nestlings, respectively, on this date. The four eggs present had mean measurements as follows: length 55.1 mm, width 36.7 mm, weight 41.6 g. Measurements of 100 Black-crowned Night Heron eggs from Massachusetts (Gross 1923) were as follows: length 51.4 mm, width 36.7 mm, weight 36.7 g. In neither case was the stage of incubation known.

Bent (1926, p. 203) gave clutch sizes of three to five eggs, and Gross (1923) found three or four eggs to be the most common size in Massachusetts. The ages of the three nestlings present in the second nest, based on culmen and tarsal lengths, were approximately 15, 14, and 12 d, respectively (McVaugh 1975). The four young in the third nest were observed only from a tree adjacent to the nest. They were twice as large as the measured brood. Assuming an incubation period of 24–26 d (Gross 1923), the clutch from which the younger brood hatched was laid around 25 April.

The three nests were checked again on 6 July 1977. At this time, two nests were empty, the young having presumably fledged. One juvenile Night Heron was perched on a tree-top about 25 m southwest of the nests. The other nest contained three nestlings ranging in age from 16–18 d down to 13–15 d. Thus, the eggs in this nest were laid about 25 May. While these nestlings were being measured, one regurgitated 22 Mummichogs (*Fundulus heteroclitus*), weighing a total of 44.4 g. Most of these had undergone little digestion. Maximum and minimum lengths of these fish were 80.0 and 45.0 mm. The nestling weighed 550 g after it had regurgitated.

Acknowledgments

Field assistance provided by C. K. Coldwell, J. S. Boates, P. W. Hicklin, and R. D. Elliot is gratefully acknowledged, as is financial support by the National Research Council of Canada and the Canadian Wildlife Service.

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Observation of a Dark-phase Ram, District of Mackenzie, Northwest Territories

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Scotter, George W. 1980. Observation of a dark-phase ram, District of Mackenzie, Northwest Territories. Canadian Field-Naturalist 94(4): 464–465.

A dark-phase ram (*Ovis dalli*) was observed in the District of Mackenzie. This is the first record for the Northwest Territories.

Key Words: Dark-phase sheep, *Ovis dalli*, District of Mackenzie.

During an aerial survey of wildlife in the Howard's Pass region, near the Northwest Territories – Yukon Territory boundary, on 15 October 1976, six mature rams (*Ovis dalli*) were seen on an alpine ridge (62° 23′N, 128° 35′W) at an elevation of approximately 1975 m (Figure 1). One of the six rams was slatey black in color, except for a white rump patch, forehead, neck and lower legs (Figure 2) which is characteristic of the Stone's sheep (*Ovis dalli stonei*). At least two of the other rams in the group had black tails. Such sheep are referred to as "fannin" or "saddle-back" sheep by hunters and outfitters in British Columbia and the Yukon. Although formerly recognized as a subspecies, they are now lumped with Stone's sheep. Within all "fannin" populations, there is a range of colors from white sheep with black tails to dark sheep.

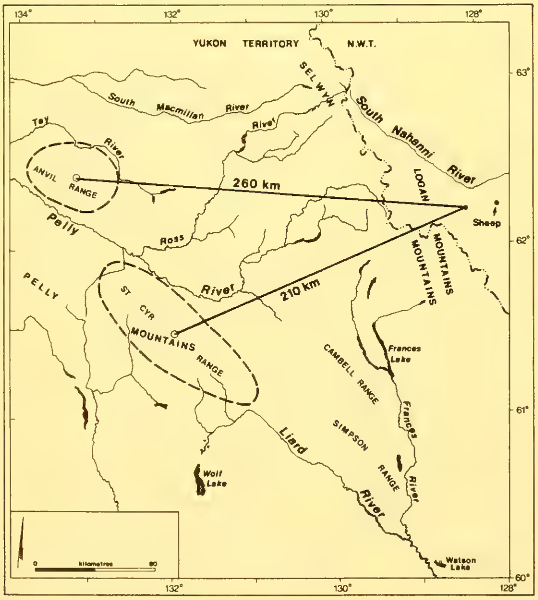

FIGURE 1. Map of the area in the District of Mackenzie in which the dark-phase ram was sighted, as well as locations of the nearest dark-phased sheep herds now existing in the Yukon.

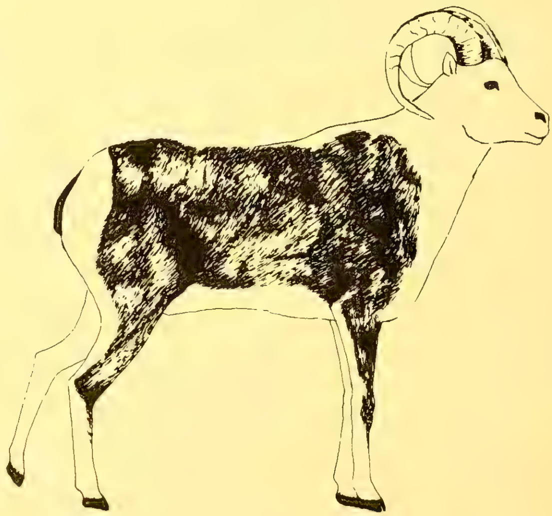

FIGURE 2. An illustration, based on colored slides, of the distribution of dark hairs over the body of the mature ram seen at Howard's Pass, Northwest Territories.

Because I had never before observed dark-phase sheep in the District of Mackenzie, a series of colored slides, 6 × 6 cm, were taken to confirm the record and for later study (Figure 3). V. Geist (University of Calgary) and M. Hoefs (Wildlife Branch, Yukon Territory government), both experts on sheep in northwestern America, examined enlarged photographs taken from the slides and consider the ram to be of the dark-phase subspecies.

FIGURE 3. This enlarged photograph, made from a colored slide, shows the distribution of dark hairs over the body of the mature ram seen at Howard's Pass, Northwest Territories.

This appears to be the first report of dark-phase sheep in the District of Mackenzie. Banfield (1974) reported no observation in the District of Mackenzie. The distribution of Stone's sheep is limited to northern British Columbia and the south central portion of the Yukon Territory according to Youngman (1975). The nearest known populations of dark-phase sheep are found in the Anvil Range about 250 km to the west and in the St. Cyr Range about 200 km to the southwest (Hoefs 1975). M. Hoefs (personal communication) believes that dark-phase sheep have been expanding their range into typical Dall's sheep (*Ovis dalli dalli*) territory during the past decade. "Fannin" color variants of the Dall's sheep were reported from eastern Alaska by Guthrie (1972).

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Yellow Wagtail East of the Mackenzie Delta

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Fraker, Mark A. and Russell N. Fraker. 1980. Yellow Wagtail east of the Mackenzie Delta. Canadian Field-Naturalist 94(4): 465–466.

An extension of the known breeding range of the Yellow Wagtail (*Motacilla flava*) to east of the Mackenzie Delta is indicated.

Key Words: Yellow Wagtail, *Motacilla flava,* Mackenzie Delta, geographical distribution, new records, breeding.

We report here evidence suggesting an extension of the known breeding range of the Yellow Wagtail (*Motacilla flava*) eastward across the Mackenzie Delta. A single adult wagtail was first observed 2 km N of Tununuk Point on Richards Island (69°01′N, 134°40′W) on 23 June 1979 (when MAF arrived). Two adults were seen 14 times from 25 June to 26 July. During this period we found the birds each time we looked for them. On 7 July, one bird was seen carrying food; on 9 July both were carrying food. Until 9 July, we always saw the birds within an area of about 200 m radius, but after that date they ranged up to 1 km. A photograph (slide) is on file with National Museum of Natural Sciences, Ottawa, Ontario.

We did not find a nest, but the tenacity of these birds to a small area for at least 1 mo and their food-carrying behavior constitute circumstantial evidence of nesting, to at least the nestling stage. The birds were seen in upland heath, with Dwarf Birch (*Betula glandulosa*) and Dwarf Alder (*Alnus crispa*). The tallest shrubs were willows (*Salix* sp.) in drainage ways; the wagtails frequently perched on these.

Despite searches for birds in the Tununuk Point area each year since 1972, no wagtails were seen until 1979. Yellow Wagtails are now seen regularly along the North Slope of the Yukon and adjacent Northwest Territories (Salter et al. 1980). The first nest of the species in Canada was found in the lower Babbage River region, Yukon Territory, on 24 June 1972 (Black 1972), and flying immatures were seen near Cache Creek, Northwest Territories on 23 July 1971 (Salter et al. 1980), about 70 km SSW of Tununuk Point. Whether the wetlands of the Mackenzie Delta that separate Cache Creek and Tununuk Point offer suitable nesting sites for Yellow Wagtails is unknown.

We thank Gary Searing and W. John Richardson, LGL Ltd., for comments on a draft of this note. These observations were made while we were engaged in research supported by Esso Resources Canada Ltd.

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Addendum

Two Yellow Wagtails were again observed in the same area on 4 July 1980. However, frequent observation effort was not possible this year.

17 September 1980

A Second Canadian Record of Audubon's Shearwater, *Puffinus lherminieri*

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Brown, R. G. B. 1980. A second Canadian record of Audubon's Shearwater, *Puffinus lherminieri*. Canadian Field-Naturalist 94(4): 466–467.

An Audubon's Shearwater, *Puffinus lherminieri*, sighted 170 km SW of Sable Island, Nova Scotia, was the first definite record for Canadian Atlantic waters and only the second for Canada.

Key Words: Audubon's Shearwater, *Puffinus lherminieri*, Sable Island, new records, biogeography.

Audubon's Shearwater, *Puffinus lherminieri*, is a tropical seabird which, in the North Atlantic, breeds in the West Indies and ranges north to Georges Bank (about 42° N) (Palmer 1962). The only Canadian record was clearly a vagrant: a bird found dead near Almonte, Ontario, in September 1975 (Godfrey 1976). The very similar Little Shearwater, *Puffinus assimilis*, from the subtropical eastern North Atlantic, has been collected once at Sable Island, Nova Scotia (Godfrey 1966). Sightings of birds that belonged to one or other of these species have been made off Sable Island (Anonymous 1979), on the southern Grand Banks (Brown 1972), south of Nova Scotia at 42°23′N, 66°11′W (Brown et al. 1975), and in the northern Gulf of Maine (Finch et al. 1978). The usual small, black-and-white shearwater seen off Nova Scotia is the slightly larger Manx Shearwater, *Puffinus puffinus*.

On 7 October 1979 I had a clear view, at a range of 100 m, of a small black-and-white shearwater on Western Bank, about 170 km SW of Sable Island, at 43°12′N, 62°01′W. It was too small for a Manx Shearwater and its flight was more rapid and different in pattern. It flew in a series of brief glides separated by seven or eight very fast wingbeats; in Manx Shearwaters, only four or five slower wingbeats separate the glides. The bird's tail seemed rather long for a shearwater but was comparable to that of Audubon's Shearwaters I have seen off Florida. A long tail is one characteristic that distinguishes it from the Little Shearwater (Watson 1966). The white on the cheeks

extended only up to, or just below, eye level—another distinguishing characteristic. The angle of view was such that I could not see the black undertail coverts, another distinguishing field mark.

The bird was in company with over 20 Cory's Shearwaters, *Calonectris diomedea*, another warm-water species, which was unusually common on Georges Bank that summer (K. D. Powers, Manomet Bird Observatory, Manomet, Massachusetts, personal communication), and which occurred unusually far north, off eastern Cape Breton, in late August (Brown, unpublished data). Surface water temperatures on Western Bank exceeded 15° C, and were warm for the area and season. Observations in previous summers indicate that a tongue of warm, saline subtropical water extends onto the Scotian Shelf over Western Bank; warm-water ichthyoplankton is associated with it (Markle et al. 1980). The incursion of both shearwaters was probably a response to these warm conditions, as was the occurrence of another tropical marine animal, a Leatherback Turtle, *Dermochelys coriacea*, off Brier Island, Nova Scotia (44° 15′N, 66° 23′W; R. Pocklington, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, personal communication), on 1 September 1979.

One may question whether this record, 170 km from Sable Island and even further from the Nova Scotian mainland, has any claim to be considered Canadian. It is from the continental shelf contiguous with Canada, however, and it is well within offshore Canadian territorial limits.

I thank the personnel of *CGS Lady Hammond* for their help and interest, and David Ainley, Roger Pocklington, Kevin Powers, and John Richardson for their comments. This is Report Number 84 in the series 'Studies on northern seabirds,' Canadian Wildlife Service, Environment Canada.

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Reports of Significant Range Extensions

Fisher, *Martes pennanti* (Carnivora: Mustelidae) in Labrador

New Record

Pitaga, Labrador, Province of Newfoundland (52°24N, 65°46W), 17 April 1978, near Quebec/North Shore Railway.

The male Fisher was confiscated from a trapper by an RCMP officer: Fishers are illegal to trap in Newfoundland and Labrador. The specimen's total length was 850 mm and it weighed 4.4 kg. Large numbers of Porcupine (*Erethizon dorsatum*) quills were imbedded in the skin and flesh, mainly in the head and neck. It was deposited in the Newfoundland Museum, St. John's, Newfoundland. Its accession number is M19 and its identification was verified by John Maunder, Curator, Natural History Section, Newfoundland Museum.

This is the first record from the Province of Newfoundland. The nearest previous records of Fishers are from Mingan, Saquenay County (50°18′N, 64°02′W) (Bangs 1898) and from the vicinity of Dufresne Lake, Saquenay County, Quebec (51°41′N, 65°42′W) (Peterson 1966— data from Harper 1961, pp. 113–114 and map 34, p. 150). These localities are 260 km S and 85 km S respectively, of Pitaga.

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Editor's Note:

This is the first contribution to our annotated list of significant range extensions, which was originally proposed in 1977 (Canadian Field-Naturalist 91(3): 224). I hope its publication as a refereed scientific paper will encourage others to prepare their new, interesting, and important records for publication.

EUGENE BERNARD SHELLEY LOGIER, 1893–1979

The "Dean" of Canadian herpetology, E. B. Shelley Logier, died on 16 March 1979, after repeated periods of surgery and illness, all borne with characteristic hope and strength. At the time of his death Shelley was 86 years of age, and had lived in retirement since 1961. He is survived by his wife Beryl, a daughter Sybil, a brother, and two sisters.

Shelley was born on 27 February 1893 in Clontarf, Ireland, a community on the Irish Sea a few miles from Dublin. This early childhood on the edge of the sea led to an interest in animals, larger and smaller. In 1906, when Shelley was 13, the Logier family moved to Canada. He credited broadminded parents as one of his earliest encouragements, claiming that unlike many boys he knew with zoological interests, he was not told there could be "no vermin in the house." Shelley and his brother Theo, shared an interest in natural history and a bedroom menagery in an old house on College Street (where the Toronto General Hospital now stands) close to Queen's Park. Shelley's interest in snakes apparently dates from this time, and Theo remembers that a DeKay's Snake (now Brown Snake, *Storeria dekayi*) caught in Queen's Park was their first captive specimen. The menagery and a microscope made the Logier brothers the envy of neighborhood boys.

This interest in natural history was encouraged and possibly channelized by contact at this time with C. W. Nash, then probably Lecturer in Biology, Ontario Department of Agriculture. The boys apparently met and collected with Nash during this period when he was preparing his checklists for the Provincial Museum. The contact continued after Nash succeeded Dr. W. Brodie to become Provincial Biologist and probably while Nash was preparing casts of fishes and reptiles for the museum.

It was, however, a talent in art, and a desire to apply that talent in the recording of nature and the activity of living things, which brought Shelley eventually to a professional involvement in natural history. As a boy Shelley could always draw well and began sketching natural subjects. After elementary school education at Landsdowne Public School, Shelley became an apprentice artist in the photoengraving shop of the Lake Brothers Company. During this period he also attended evening classes at the Ontario College of Art for two years. Just as his contact with a practising natural historian stimulated his interest in that area, an interesting contact also furthered his interest in art. Theo Logier recounts that W. Broadhead lived for a time in the Logier household, and as a result the Logiers enjoyed the visits of Broadhead's friends, among them Tom Thomson and Arthur Lismer. This contact strengthened a natural artistic talent of both the Logier boys, each of whom utilized art as part of later professional activities.

Shelley became associated with the Royal Ontario Museum of Zooloogy (ROMZ) on 1 December 1915, at the age of 22. The records indicate simply "without pay." On 1 September 1916, he was officially appointed on a half-time basis as "Artist." This was followed by annual 10-month appointments from 1917–1921. Apparently full-time employment at ROM came in 1921.

Natural history of any kind was secondary to Archaeology at ROM until the occupation of the "new" building (east wing and connecting wing) in 1932. There were simple zoological displays in the original 1913 building (west wing) at the north end of the upper floor where the whole of the Royal Ontario Museum of Natural History (1913), and later the Royal Ontario Museum of Zoölogy (1914), occupied a space 104 × 62 feet. Shelley was involved in these early displays, at least by 1918, when he was painting a set of casts of Canadian fishes.

As the early zoological collections grew there was an informal division of labor. Shelley's interest in reptiles led naturally to his being asked to take on the responsibility for the amphibians and reptiles.

The compartmentalization of activities in herpetology at ROM changed over the years and the history is now no longer clear. There was a Division of Amphibians and Reptiles, separate from that for fishes, listed in 1937 with Shelley the sole participant. The fish and herpetology divisions were joined, as the Department of Ichthyology and Herpetology in 1950, separated again in 1959, and rejoined in 1962. Within these frameworks Shelley was promoted to Assistant Curator in 1947, Associate Curator in 1950, Curator (in charge of the Department of Amphibians and Reptiles) in 1959, and was made an Honorary Member of the ROM in 1960. Shelley retired from the ROM on 30 June 1961 after 46 years as artist, natural historian, and herpetologist.

In the years 1919–1933 Shelley took part in field trips to various parts of Canada: the Atlantic coast; Ontario including Muskoka District, Algonquin Park and lakes Erie, Ontario, Abitibi, and Superior; Quebec (two trips); Pacific coast (two trips). After 1933 his participation in the combined field trips seemed to decrease, although he continued to collect locally. On these trips, as well as collecting and sketching amphibians and reptiles, he painted field sketches — details of fins, heads, and body sections of fishes, and of aquatic plants. These he used later in the life-like painting of the gallery models and displays.

A small study collection of herpetiles existed at the Royal Ontario Museum of Zoology prior to Shelley's

E. B. SHELLEY LOGIER in his office at the Royal Ontario Museum about 1958. Photograph by Ray Webber, Toronto.

appointment. As with the specimens representing other groups of animals, the herpetology collection had its origin in the material transferred in 1914 from the earlier Biological Museum of the University of Toronto. To this was added the specimens transferred from the Ontario Normal School and Provincial Museum in 1933. A major part of the University of Toronto collection was a single unit of 2500 specimens purchased from or donated by J. H. Garnier, a physician in Lucknow, Ontario. Dr. Garnier was particularly interested in reptiles and the collection was rich in reptiles from around the world, as well as Garnier's local specimens. Also included were his handwritten notes on amphibians and reptiles.

How early Shelley applied himself to the herpetile collection, I was unable to determine. In 1925 he published, in *The Canadian Field-Naturalist*, the first of his papers on herpetiles, and in that year the ROM Annual Report first records the accessioning of specimens of "Amphibians and reptiles resulting from staff fieldwork." By the period 1928–1930 Shelley had catalogued, labeled and stored in systematic order the growing herpetile reference collection, and had published his first paper in *Copeia*, the journal of the American Society of Ichthyologists and Herpetologists (on melanism in Common Garter Snakes, *Thamnophis sirtalis*). Sections by Shelley, on amphibians and reptiles, had by this time become a regular part of faunal surveys carried out and published by ROM. In 1936 Shelley initiated his long-term study of the taxonomy and distribution of the amphibians and reptiles of Ontario, which over the years resulted in many very useful checklists, illustrated handbooks, keys, and biological notes.

The period 1942–1950 included field trips to Favourable Lake, Vermillion Lake, and Fort Severn in Ontario, a study of the Wood Frog (*Rana sylvatica*), and preparation of checklists and reference collections for provincial agencies, including Manitoba. The government of Ontario called on Shelley for assistance in a study of the effects of DDT on animals in Algonquin Park. The ROM became part of the University of Toronto during this time and Shelley's previously informal student-instructing became part of a course in the Department of Zoology.

Between 1952 and 1958, Shelley concentrated on collection management and publication. He completed the book *Frogs, toads and salamanders of eastern Canada*, the handbook *From egg to tadpole to frog*, the first edition of the *Checklist of amphibians and reptiles of Canada and Alaska*, and the book *The snakes of Ontario.* He continued a study of the reptiles of eastern Canada and had begun a revision of the 1939 Handbook for Ontario and one on Eastern Canada. None of these were completed, however. During this period he was also involved in the planning for a new major museum gallery entitled *The Gallery of World Reptiles*, which was not finished and opened until after his retirement.

Shelley participated also in organized activities in natural history. He was a charter member of the Brodie Club, one of the older and very active local naturalists organizations, and attended the first meeting in 1921. He continued to attend regularly until 1944, became a less active Corresponding Member in 1946, but continued to attend the anniversary gatherings which marked every hundredth meeting. He gave a paper at many of the meetings and although most of these were on herpetiles, he gave one on chipmunks and in 1923 was part of a club committee studying *Microtus*. He was also a long-standing member of the Federation of Ontario Naturalists. Early in his career he joined the American Society of Ichthyologists and Herpetologists, was involved when that society met in Toronto in 1940, and continued his affiliation until he retired.

Retirement ended the formal part of Shelley's long professional association with the study and display of animals. It did not, however, end his interest in amphibians and reptiles nor did it end his influence on people concerned about them. Shelley became deeply involved with the Canadian Amphibian and Reptile Conservation Society (CARCS), a group of mostly non-professional people with sincere interests in herpetiles, in studying herpetiles, and in keeping them in captivity. He was twice President of that society, he was appointed Honorary President in 1972, and the CARCS executive usually met in the Logier home.

Shelley was perturbed that amphibians and reptiles were rarely considered in statements of the impact on the environment of man-made changes. His attitude was that those who are concerned for the preservation of all living things must direct their attention to the individual, the species, and the environment, not just to one or the other. He was also concerned about endangered herpetiles, and with CARCS suggested to the provincial government aspects of legislation which would protect them.

Shelley Logier leaves us at least three legacies. His art work is probably the first of these. From the beginning it provided excellent, sensitive illustrations, first of fishes and later of herpetiles. It is sad that some of his later art works eluded his control and were exploited commercially without credit. Art of a lighter nature also persists. Shelley apparently enjoyed a role as a natural history cartoonist. Cartoons of that nature, as well as very recognizable and puckish caricatures of fellow staff members, were a regular part of commemorative albums prepared for the retirement of various individuals.

The second legacy is the fact that he made himself universally available to those he felt had a true interest in herpetiles. This included many children whom others might have tried to avoid. Some of those children and students who enjoyed his quiet, patient help now form part of the very small group of professional herpetologists in Canada.

The third legacy is his work, published or conveyed in discussion and letters. He pioneered in herpetology in Canada. His published work might be judged modest in quantity (46 titles in 40 years) but he was careful, thorough, and in the early years most of his time was taken by other museum responsibilities. His early faunal studies provided a base to which others could add. His taxonomy was cautious and conservative and while the nomenclature published in the 1961 *Checklist of amphibians and reptiles of Canada and Alaska* had fallen behind Shelley was very aware of the complexities of variation. He pointed out ways in which analysis of Ontario material contradicted existing concepts. His own interpretations of areas in need of study, and the two editions of the checklist, have had considerable impact on the subsequent study of herpetiles in Canada. He was the first to present spot distribution maps for Canada (1955) making possible the publication of complete North American range maps by R. Conant, in his 1958 *A field guide to reptiles and amphibians of eastern and central North America*. He carried on an extensive correspondence with herpetologists in the United States, provided ideas and information on Canadian species and populations, and of course, sent material on loan for them to examine.

His ability to convey his interest, and enthusiasm, both in words and in illustration, and particularly in his interpretive writings, led to a much enlightened lay attitude toward herpetiles, and toward snakes in particular. Shelley was long involved in all reported cases of snake bite in Ontario and in an attempt to place the danger of death from Ontario's one poisonous snake at a sensible level. He regularly convinced cottagers of their greater danger driving to the cottage as compared to the likelihood of a mortal wound from a Eastern Massasauga, *Sistrurus catenatus*.

It is unlikely that there were more than 500 specimens of amphibians and reptiles in the ROMZ collection when Shelley joined the museum in 1915. The number recorded in 1939 was 6659 in addition to the original Garnier collection. When Shelley retired in 1961 the collection stood at close to 10 000 specimens. The worthwhile work started by Shelley Logier is being carried on in the department. It is hoped, however, that the need to build on the important base that he created will soon be properly recognized by the appointment of a full-time herpetologist to succeed him (after a hiatus of 20 years). This would be the best way to assure that the study, teaching, and display of amphibians and reptiles, begun at ROM by E. B. S. Logier will continue.

I thank Beryl and Theo Logier, Bev Scott, Francis Cook, Terry Shortt, Barbara Froom, Wayne Weller, and Howard Savage for helping to make up for the meagre knowledge of Shelley's background available from ROM records and from my acquaintance with him.

E. J. CROSSMAN

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News and Comment

Book Review Editor's Report

Each issue of *The Canadian Field-Naturalist* provides a list of New Titles, publications of interest to Canadian field-naturalists, with an average of 70 to 75 in each issue. The listings are assembled by the Book Review Editor from books received, announcements by publishers, other bibliographic listings, and recommendations received from readers and the membership of The Ottawa Field-Naturalists' Club. Information on new publications appropriate for listing is always welcome. When available, listings include author(s), publication date, title, publisher, size, and cost.

In each issue an average of 14 of these books are reviewed. An attempt is made to review the books of most potential interest to field-naturalists with preference given to the Canadian environment. Books are often received without special request from the publishers. For appropriate books, reviews are solicited either by indicating (with a †) in the list of New Titles the books that are available and awaiting volunteers with the appropriate expertise, or by actively soliciting reviews from individual members. Volunteers are always welcome and should write to the Book Review Editor and give specifics of their area of interest. About three-quarters of the average 75 books received are reviewed each year. Complimentary copies of some books with topical information are requested from the publisher and over 90% of such requests are honored.

An attempt is made to have all books reviewed within two or three months order to supply timely information to our readership and to keep a good relationship with publishers who supply complimentary copies. Reviews are normally submitted with 1 to 3 pages double-spaced typing and generally indicate the purpose of the book, whether this purpose was met, and the value of the book to our readership. Reviews are edited prior to publication.

The following table summarizes the book review statistics for Volumes 92 and 93 of *The Canadian Field-Naturalist*:

	1978 (Volume 92)	1979 (Volume 93)
Books requested from publishers	34	19
Books received from publishers (many without request)	73	76
Books sent to reviewers	57	39
Reviews completed	72	53
Reviews published	44	72
New titles listed	303	277

WILSON EEDY,
Book Review Editor

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Funding Needed for Study of Vancouver Island Marmot

The Vancouver Island Region of the Federation of British Columbia Naturalists is determined that adequate measures be taken to ensure the survival of the Vancouver Island Marmot, *Marmota vancouverensis*. This marmot occurs only on Vancouver Island and only four active colonies are known. The total population is thought to be between 50 and 100 animals and these live in the subalpine meadows of some of the higher mountains in the southern half of the island.

The Vancouver Island Marmot was declared, on 8 March 1980, one of British Columbia's rare and endangered species. More work must be done so recommendations can be made on how to preserve this species. For example, could some animals be moved from existing colonies to vacant habitats and there successfully establish new colonies? How much of their habitat should be protected for their survival?

The most noticeable difference between the Vancouver Island marmots and others is the distinctive watch patch around the nose and an irregular white streak on the chest and belly contrasting with the general dark brown coloration.

Anyone wishing more information regarding the studies or to donate money for it should contact Dave Routledge, Vancouver Island Marmot Preservation Committee, Site 11, Box 105, R.R.1, Lantzville, British Columbia V0R 2H0 (telephone 604-390-2257).

Fourth Annual International Wildlife Film Festival

The University of Montana Student Chapter of The Wildlife Society will sponsor the Fourth Annual International Wildlife Film Festival in the spring, 1981. The chapter initiated the festival to encourage film makers to produce better wildlife films, both in technical quality and content. Such films are essential in teaching ecological and environmental concepts to the public. These films may be the only contact many people have with wildlife, and so the messages they convey are critical.

The deadline for submission of applications and films is 14 March 1981. All entries must have a predominantly wildlife theme and have been produced or released during the 1980 calendar year. A panel of highly qualified film makers, humanists, and biologists will judge both amateur and professional categories of wildlife films before the Festival.

The winning films will be shown to the public on 10, 11, and 12 April 1981, at the University of Montana campus in Missoula. Panels and workshops of film makers and biologists will also be a feature during this weekend, along with an art exhibit of wildlife paintings and photos.

Information, rules of eligibility, application forms, and the festival agenda can be obtained by writing or calling: Wildlife Film Festival, Wildlife Biology Program, University of Montana, Missoula, Montana 59812; telephone (406) 243-5272.

World Heritage Recognition for Dinosour Provincial Park, Alberta

Dinosaur Provincial Park in southern Alberta was officially dedicated as a UNESCO World Heritage Site on 19 June, during an international celebration. To date 30 species of dinosaurs have been found in Dinosaur Provincial Park and 30 major museums around the world hold fossil collections from the park. No other dinosaur field of comparable size has yielded so many and such a variety of well preserved specimens from the Upper Cretaceous period of the world's history.

Dinosaur Provincial Park is the first provincial park among the 57 natural and cultural heritage sites that have been named to the World Heritage List. The list was established under the UNESCO World Heritage Convention, adopted in 1972 as a treaty among nations concerned about the protection of the world's cultural and natural heritage areas. L'Anse aux Meadows, Newfoundland, the only Viking Period Norse settlement in North America, Kluane National Park in the Yukon, and Nahanni National Park in the Northwest Territories are other Canadian sites that have been named to the UNESCO World Heritage List.

Seasons — the Federation of Ontario Naturalists Magazine

Seasons is the new name of the Federation of Ontario Naturalists (FON) magazine. In March 1980 it replaced the *Ontario Naturalist*, a magazine for nature enthusiasts and conservationists, not only with a new name but with a more popular content and increased distribution. With the new "editorial focus to run more popular articles that will appeal to general-interest readers as well as the died-in-the-wool naturalist" *Seasons* presents a completely new image.

Tied in with the broader editorial scope is a new national focus: *Seasons* will cover nature issues of national concern to all Canadians.

Seasons is published quarterly by the FON and is available by subscription from 355 Lesmill Road, Don Mills, Ontario M3B 2W8. The rate of $17 for one year includes full membership in the FON. Published quarterly, *Seasons* is also available at newstands. Distribution is being handled by Canadian Periodical Publishers Association, and eventually by Coast to Coast Distributing Company.

Protection of Whales and Dolphins

The Whale Society of Edmonton (P.O. Box. 476, Substation 11, Edmonton, Alberta T6G 2E0) is campaigning to protect whales and dolphins by trying to influence the Canadian government and hence Canada's position at the International Whaling Commission (IWC) meetings. The society has asked concerned persons to write to The Honorable Romeo LeBlanc, Minister of Fisheries and Oceans, Ottawa, Ontario K1A 0C6 asking that Canada actively adopt a vigorous and progressive policy for the national and international protection of cetaceans (whales, dolphins, and porpoises), their ocean habitat, and their food resources. So far, at the IWC, Canada has aligned itself with the whaling interests rather than with the growing number of countries concerned with whale preservation.

The Ottawa Field-Naturalists' Club

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Errata

Spawning migrations, age and growth, and summer feeding of White and Longnose Suckers in an irrigation reservoir by Bruce A. Barton

Canadian Field-Naturalist 94(3): 300–304; 1980.

On page 300 the second sentence of Material and Methods should read "Both traps were checked daily at the beginning and peak of sucker migrations and every 2-3 d during the latter part of the run." On page 304 (left column) twoi in line 4 should read "two" and National in the Barton and Bidgood (1980) reference should read "Natural."

Book Reviews

Zoology

Shorebirds in Marine Environments

Frank A. Pitelka (Editor). 1979. Studies in Avian Biology Number 2. Cooper Ornithological Society, c/o Department of Biology, University of California, Los Angeles, California 90024. viii + 261 pp. Paper U.S. $8.00 plus 0.90 postage and handling charges.

This recent publication of the Cooper Ornithological Society is the second volume of the new *Studies in Avian Biology* series, a successor to the now defunct *Pacific Coast Avifauna* monograph series. This volume, however, is not a monograph, but a collection of 26 papers presented in 1977 at a symposium on shorebirds, under the aegis of the Pacific Seabird Group, and organized by Frank A. Pitelka. Pitelka, as organizer and editor, presents us with a fascinating combination of communications on various aspects of shorebird biology and habitat conservation. The symposium, by the way, was organized not only for avian biologists, but also for the representatives (field workers and administrators) of various federal and state agencies.

The objectives of the symposium were twofold. First, the study from the "standpoint of basic knowledge" and the expansion of the research front, of the distribution, migration, and ecology of shorebirds; a second orientation emphasized the conservation and the management of coastal wetlands (defined as all lands subject to regular and periodic tidal influence) important to shorebirds.

The communications are divided into two main groups. Part One deals with the distribution, migration, and conservation of shorebirds and their habitats. Although most of the seventeen papers in this section concern research carried out on the Pacific Coast of North America, two of the papers are of studies of shorebirds in Latin America and two others were communicated by British researchers. Pitelka's introductory paper deals with shorebird biology and distribution along the Pacific Coast from a fairly global point of view. The accompanying tables, figures, and graphs present much well organized information, and the whole paper serves as an admirable introduction to the other papers presented at the symposium.

Although shortage of space does not permit a detailed review of the individual papers, the following brief descriptions will serve as a guide to the various research areas dealt with in these communications. Shorebird censusing was extensively used by researchers. A team from the Point Reyes Bird Observatory used censusing to investigate the seasonal abundance, biomass, and species composition of shorebirds during a five-year period. This study underlines the importance of wetland areas and the detrimental effects their destruction may have for nesting, migrating, and wintering shorebirds. A cooperative research project of the Canadian Wildlife Service and the Manomet Bird Observatory provided the first account of Semipalmated Sandpiper (*Calidris pusilla*) "migration patterns, and strategies of populations from different parts of the arctic." According to the authors, the knowledge thus gained "is a prerequisite for the identification of sites that are of critical importance to the wellbeing of shorebird populations." The authors of "Seasonal habitat use by arctic Alaskan shorebirds" aimed to determine the way increasing developments of "North Slope" energy resources could change various coastal habitats. Other papers in Part One treat areas of prime importance to migrating shorebirds, such as Nelson Lagoon along the north-central Alaskan Peninsula, and the Copper River Delta system and Prince William Sound areas of southern Alaska. The consequences of possible environmental disturbances to these important staging areas could affect enormous numbers of shorebirds that rely on these stopover places for feeding and rest in their spring and fall migrations. The migratory shorebird populations of the Copper River Delta and Prince William Sound region have been censused since the early 1970s, and it has been estimated that about 20 million shorebirds, mostly Dunlin (*Calidris alpina*) and Western Sandpiper (*Calidris mauri*), pass through the region in spring migration. Both species, and 23 other species occurring regularly in large numbers, use these staging areas for the replenishment of fat reserves needed for further migration and reproduction. The richness and importance of this region may be illustrated by the fact that up to half a million shorebirds were utilizing, at one time, the 50-km^2 area of Orca Inlet, near the western Copper River Delta. The relatively new awareness of the importance of southwestern Alaska as staging area for migrating shorebirds influenced the Alaskan State Administration's proposal of a bill to the state legislature to create a "Copper River Delta Critical Habitat Area." This is an important step in coastal wetland conservation in the face of increased oil tanker use because of the Trans Alaska Oil Pipeline.

The preservation of coastal wetland habitats is emphasized in a study of California's coastal wetlands. It is sobering to consider that, as estimated by the California Department of Fish and Game, two-thirds of the 381 000 acres of prime coastal wetlands of this state, extant at the turn of the century,

have since been lost to developments. Of the remaining areas, many belong to local agencies, and in spite of successful recent efforts, still much work needs to be done towards acquiring and conserving coastal wetlands.

The second part of the volume, entitled "Ecology," starts with the abstracts of four papers given at the symposium. Not being able to read them in their entirety presents the only frustrating aspect of this publication. The remaining five papers deal with shorebird ecology of regions as widespread as the Marshall Islands, Britain, British Columbia, California, and the Panama Canal Zone. The researchers working on Enewetak Atoll, Marshall Islands in the Pacific Ocean, investigated the biology of five species of non-breeding shorebirds that remained on this wintering ground during the boreal summer. The various aspects of this study include sex ratio, reproductive conditions, plumage and molt, fat content, and flight range of the five species. Another paper deals with a study of the Black Oystercatcher (*Haematopus bachmani*) on the west coast of Vancouver Island. On an area of protected mudflats, the distribution and daily movement of birds on the mudflats (to and from the feeding area and movements within the feeding area) were investigated. The size and type of prey and the rate of feedings were analyzed. In "Feeding ecology of three species of plovers wintering on the Bay of Panama, Central America," research was carried out on the feeding habits and types of prey consumed of the three species of plovers found in winter in the Canal Zone. In "Territoriality of non-breeding shorebirds" the authors raise a "fundamental ecological and evolutionary question: Why should a bird indulge in territorial defense while others survive non-aggressively?" In order to elucidate the extent of non-breeding territoriality, several of its features were examined, such as territory stability and size, aggressive displays, territorial commitment and alternative strategies, and adaptive consequences. In a British contribution, the final one of this volume, "The energetics of foraging by Redshank, *Tringa totanus*," the results of a field study, conducted in southern England and northern Scotland on the selection of feeding places and types of prey taken by the Redshank are summarized.

This volume of research communications provides us with an overview of the research orientations and recent achievements of avian biologists focusing on "shorebirds in marine environments." The necessity of further, long-term research is constantly emphasized. The papers are well presented, thought provoking and of consistently high quality. The tables, figures, maps, and photos accompanying the text are helpful. This volume is a must for those seriously interested in the study of shorebirds. For the price, it is a bargain.

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Faunal Remains from Fort White Earth N.W. Co. (1810–1813)

By I. Hurlburt. 1977. Human History Occasional Paper Number 1. Provincial Museum of Alberta, Edmonton. 107 pp. Free.

Zooarchaeology is a young discipline and generally has dealt with faunas of sites older than the historic period. It is encouraging to see that this field of study is expanding and the number of its practitioners increasing.

Hurlburt has done a reasonable job of integrating the three factors she considers important for interpreting historic faunal remains: archaeological, historical, and zoological, with the emphasis on the first two. She seems to have two objectives in mind in this publication; the first and most obvious is the description of the faunal remains from the site and comparison with the historical records. Secondly she seems to be attempting to write a textbook on zooarchaeology and devotes a large portion of the text to discussion of commonly encountered problems and methodology. She succeeds quite well with her first objective but does poorly in the second. Because of the mixing of these two goals she sometimes forgets her audience. The change in tone and format, from interpretation to teaching, interferes with one's train of thought.

Her historical data is excellent and she has done a fine job of integrating it with the available faunal remains. Her descriptions of butchering marks, bone breakage, and the various species are clear and well integrated with the historical descriptions. I found the discussions on the use of marrow and pemmican production informative but would have achieved a clearer understanding if she had spent as much time explaining some of her terminology for this section as she had for other sections.

There are a number of inconsistencies in the paper: she states that the preservation of faunal remains is directly related to the degree of burning or the way in which buildings collapsed and not due to varying

resistance of the faunal materials themselves, but later states that the bones from very old animals will deteriorate more rapidly than will the bones from younger animals subjected to the same conditions. Cut rib sections are 11–20 cm in length in one discussion but 2–6 in in length in another. After a thorough discussion showing that the bones were broken for the manufacture of bone grease we find out that there is no mention of bone grease production in any of the historical records. Although there is a constant reference to parkland as opposed to forest-belt animals she does not define the differences in these two habitats. Some statements are just incorrect: I do not see how she could get marrow from the ulnae of Moose and deer, and although sturgeons do not have scales their skin is covered with dermal plates which are preserved and often recovered in archaeological excavations.

I also have to take issue with her suggestion that animal anatomy books for artists are a good source for the determination of the placement of musculature because there are plenty of other publications which would be more accurate and reliable. I also question her statement that drinking water was a source of vitamins and minerals which acted as a supplement to the engagee's diet. Minerals, possibly, but vitamins, not likely.

As I have mentioned, part of the paper appears to have been designed to act as a textbook in order to introduce the student of archaeology to some of the problems encountered in the analysis of a faunal sample. It is this aspect of her publication that is lacking. Although she emphasizes techniques throughout the paper, in many areas she has neglected the details. In the Introduction she notes that backdirt was screened to recover small animal remains, but the size of screen is not mentioned. One is also left wondering whether all squares were excavated exactly the same or whether the recovery of large bones from one square and small bones from another is due to differences in excavation technique. I did like her idea of the fore- and hind-quarter method for calculating meat percentages, and her discussion of why it corrects for the absence of whole animals in a site is well done. In fact throughout the paper she does an excellent job in pointing out the problems that may be encountered throughout the process of analyzing a faunal sample, from species identification, to aging, sexing, and interpreting patterns of bone breakage. But there is a large gap between pointing out problems and providing valid methodologies for overcoming them. Although these lists in themselves are of value to a beginning student and should be present in an introductory text, most professionals are aware of them and their inclusion detracts from the meat of the paper: the interpretation of the faunal remains at Fort White Earth in the light of historic evidence. Although an appendix is available, which is supposed to explain how the various results and interpretations within the body of the paper were achieved, the discussions are sketchy.

There are no illustrations of any kind except an X-ray picture of a Bison on the cover. A few illustrations in the text would have been extremely informative and a general location map and a map of the excavations would have helped. There are 18 tables; some of them are informative but others like Table 12, "Summary of the data on phases of maturation on the diaphysis and epiphysis on Wapiti, Moose and Bison and the sample sizes" are just confusing.

This should have been published as two separate papers, one on the faunal remains from Fort White Earth, as the title implies, and another on problems in faunal analysis. Both areas are thoroughly intermixed and it takes some sifting to extract the kernels of good information from the chaff. The paper indicates a lot of potential but the author has a way to go before reaching the level of her predecessors in historical zooarchaeology.

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Management and Biology of Pacific Flyway Geese

Edited by R. L. Jarvis and J. C. Baronek. Osu Book Stores, Corvallis, Oregon. 346 pp., illus. Paper U.S. $5.50.

This publication is the result of a symposium sponsored by the northwest section of the Wildlife Society that was held in Portland, Oregon on 16 February 1979. Twenty-four papers were given in five sessions including Taxonomy and Classification, Breeding Biology, Molting and Migration, Wintering Biology, and Status and Management.

B. D. Krogman, in a paper from the taxonomy session, used the discriminant function analysis method of data reduction to provide a set of distinct morphological parameters effective to separate common White-fronted Geese (*Anser albifrons*) from the rare Tule White-fronted Geese (*A. a. elagasi*). This paper together with R. D. Bauer's historical account on Tule White-fronts from southern California provide much information on this rare subspecies. I noted

that the taxonomic naming of these subspecies is different in each paper; Bauer's reference appears to be correct.

Papers in the breeding biology session are not all directly related to this topic. L. J. Blus et al. describe the effects of pesticide-treated grain on Canada Geese (*Branta canadensis*) inhabiting northern Washington. High pesticide (*heptachlor epoxide*) levels were found in the eggs of birds nesting in the study area. The application of potentially toxic insecticides apparently has a very adverse effect on breeding Canada Geese from this area. T. McCabe reports in a paper on Canada Geese breeding near Umatilla, Oregon, that hydroelectric development is restricting the breeding success of the population in this area.

Six papers describing the results of goose band recoveries along the west coast constitute the section on molting and migration. A paper by J. T. Ratti and D. E. Timm stresses the fact that bias can occur when goose band data are not adjusted for different hunting pressures on the collection sites. The authors provide convincing evidence from a hypothetical study that could overestimate the population level of geese using data not corrected for variable harvesting procedures.

In the short session on wintering biology some interesting information is presented on the life histories of geese from southern areas of the USA. G. W. Kramer et al. offer an interesting discussion on the biology of Black Brant (*Branta nigricans*) during its stay in Baja, Mexico. This paper presents much data on population dynamics, behavior, diet, as well as human interaction and disturbance of Brant from coastal Mexico. This work is an impressive collection of results on Brant from an area not previously studied in detail.

The final session of the symposium on status and management provides information on current management-oriented studies being carried out on the Pacific flyway. D. E. Timm et al., in a paper on the evolution of management practices for dusky Canada Geese (*Branta canadensis occidentalis*) on the west coast of Alaska, outline the changes in management techniques for this species over the last 30 years. The advancement of management procedures in this area is quite impressive and the future appears promising for the dusky Canada Geese.

A critical aspect of west-coast goose management is the preservation and restoration of habitats. It is obvious from this symposium that habitat depletion continues to be a problem to the maintenance of substantial goose populations, especially in wintering areas in the United States.

The text suffers from several drawbacks which I believe could have been avoided. The main problem is the lack of a standard format for all papers. A further deficiency is the great amount of unrelated data that is presented. Lesser but irksome imperfections are the presence of typographical errors, illegible maps and graphs, improper literature citations, and confusion of some scientific names. For these reasons, I do not recommend this work to biologists not working specifically with geese; however, I would recommend this work to biologists or individuals directly involved in goose biology and management because the tremendous amount of information presented could be useful if closely scrutinized.

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Research is a Passion with Me

By Margaret Morse Nice. Edited by Doris Huestis Speirs. 1979. Consolidated Amethyst Communications, 12 Crescent Town Road, Unit 310, Toronto. 336 pp., illus. Cloth $12.95; paper $9.95.

The title of this excellent book is right on — Margaret Morse Nice had a passion for research. One grieves only that so little was done to facilitate her work. During her lifetime she published scores of scientific papers and books, and reviewed 3280 works for *Bird-banding,* but she was never awarded any grants; without the extensive financial support from her husband she would have been unable to attend the 22 national and international ornithological meetings where she usually presented a paper and was emotionally encouraged to carry on her work. Unlike her physiologist husband, she was unable, because she was a woman, to join the Columbus, Ohio, Wheaton naturalists' club where she would dearly have loved to discuss her Song Sparrow research. On top of that, she did not have an adequate study until she was 53 years old.

Margaret Morse was born in 1883, one of seven children, to a professor of history at the University of Massachusetts. The family lived on a two-acre lot in Amherst where Margaret developed a deep interest in nature. She attended Mount Holyoke College, studying natural sciences and various languages which would later help her search the scientific literature in seven languages. She did Master's work from 1907 at Clark University on the food of the Bobwhite, but although she wanted also to earn her Ph.D. she was instead urged to return home, as a dutiful daughter

should. She did so, and soon after married.

Margaret Morse Nice was too busy to carry on her research on birds during the next few years as she was occupied in Norman, Oklahoma, producing and raising a family of four daughters. Instead, she turned her attentions to the development of speech in her children, collecting and classifying the words of their vocabulary at various ages and analyzing them by parts of speech and by interest. She published 15 papers on child psychology and was awarded a belated Master's degree for this work in 1926.

Margaret Nice's life changed in 1919 when, at the age of 36, she again turned her full energies to research on birds. The catalyst was a newspaper item stating that the Oklahoma open season for the Mourning Dove would perhaps begin on "August 15 when all the young doves are off the nest and strong fliers." She wrote, protesting this inaccuracy, to the local newspapers and then proceeded to find, in September, 28 new Mourning Dove nests in three of which the young were not fledged until October. Earlier she had helped keep the Bobwhite in Ohio off hunting limits when she had estimated that one Bobwhite hen ate in one season 75 000 insects and five million weed seeds. During the next seven years, Margaret Nice studied the birds throughout Oklahoma, her research culminating in *The Birds of Oklahoma* published with her husband in 1924 and revised in 1931.

In 1927 the Nices moved to Columbus, Ohio, where Margaret began her famous ten-year study of the behavior of the Song Sparrow. It is perhaps fitting that this common bird, which other zoologists had overlooked, would open important vistas to behaviorists and make her one of the most eminent ornithologists of all time. She banded individuals and watched them continually on a wild area called Interpont which, to her distress, was gradually degraded over the years as underbrush was cut down and weeds were destroyed. Yet in one year, in spite of local boys who shot at her charges, she followed the fortunes of 69 males on 40 acres. One of the males she had studied for eight years thrilled her by singing 2305 songs in one day. Later she studied the behavior of captive birds which she collected from nests when they were a week old, patterning this work on that of Konrad Lorenz whom she visited in 1938 in Austria.

Nice's research work was eventually rewarded with the friendship of world-famous birders, the presidency of the Wilson Club, a fellowship in the American Ornithologists' Union, the Brewster Medal of the AOU for her two books on the Song Sparrow, and an honorary degree from Mount Holyoke College. In 1952 a Toronto-based women's Ornithological Club was named after her, organized by Doris Huestis Speirs because women were not then allowed to join the Toronto Ornithological Club. Doris Speirs has edited this present work, written by her friend Margaret Nice shortly before her death at age 90 in 1974, adding the scientific names of birds and a comprehensive index. There are also a few photographs and some sketches by Margaret Nice. The text is easy to read and should delight all those who admire this indomitable woman and who love birds.

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Animal Behavior: an evolutionary approach

By John Alcock. 1979. Sinauer, Sunderland, Massachusetts. 2nd edition. x + 432 pp., illus. U.S. $16.

This book should be used by those interested in acquiring a basic understanding of the interrelationships between natural selection and animal behavior. The text should continue to be utilized internationally by second- and third-year college introductory animal behavior courses. This edition is much improved over the first. It is rearranged, more readable, and better oriented to behavioral ecology. Many of the peripheral subjects appearing in the first edition are now deleted. Each chapter has a helpful introduction, summary, and suggested reading and related film list.

Although this book has its shortcomings, it has many good arguments supporting or rejecting hypotheses that all animal behaviorists think about. After the index is consulted, the term is easily found on the text-page since most indexed terms are in uppercase print. The author, subject and film (with addresses for ordering) indices make the text a useful reference. There are good discussions of proximate versus ultimate causes of animal behaviors, instinctive versus learned behaviors, the physiology of behavior and the evolutionary ecology of behavior.

It is important that a student be able to associate a concept with a particular researcher and publication date. This book fails in this regard by using numbers for original references instead of authors and publication dates. I found myself turning to the bibliography at the end of the book two or three times per text-page to ascertain who was being cited and when the work was published.

Most of the figures are ambiguous. The photos are poorly reproduced and one is upside down (see p. 97). Throughout the text, typographical errors are few; however, the worst errors I have seen in any book are on pages 69–71 where several sentences have no beginnings or endings.

There are a few conceptual problems in this book. Alcock has problems with territorial economics (chapter 8). He sees animals as "dumb" harborers of "smart" genes. For instance, the reader is led to believe Alcock would support the theory: An animal doesn't get hungry, he eats when natural selection says he should (cf., p. 170). Very few arguments support animals choosing their behavior. When Alcock is confused he concludes that the study of animal behavior has its problems.

Overall, Alcock does not have a good grasp of the literature. More examples are needed to fit his conceptual arguments. Without examples, students of animal behavior cannot associate a concept with a natural system. Further, Alcock rarely uses scientific names for taxa and this inhibits generic comparisons. Thus, even though this edition is a vast improvement over the first, its treatment of animal behavior is not rigorous enough for fourth-year and graduate-level students. Otherwise, I recommend it for the beginning animal behavior course as long as there are many animal examples in the lecture portion and the instructor is vigilantly aware of the text's shortcomings.

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Care and Rehabilitation of Injured Owls: a user's guide to the medical treatment of raptorial birds and the housing, release training and captive breeding of native owls

By Katherine McKeever. 1979. Rannie, Beamsville, Ontario. 112 pp., illus. $10.

Fortunately for owls and those interested in them, Katherine McKeever has put into print the knowledge she and her husband have acquired since the inception in 1967 of the O.R.R.F. (Owl Rehabilitation Research Foundation) in Vineland, Ontario for the treatment and rehabilitation, to captive breeding or release, of injured owls. From small beginnings the project has grown to a large complex, and Mrs. McKeever has written a very complete analysis of the foundation's work, its aims, problems, and accomplishments.

As she points out, many species of owl are now, or soon may be, endangered, and the knowledge gained from treatment of common birds such as the Great Horned Owl can be of value with the rarer species. Her book covers in great detail the steps to be taken, from the initial capture and transportation of the injured bird, to admitting procedures (and often the painful decision of humane euthanasia); diagnosis and remedial treatment of the wounds, infections, fractures, and removal of parasites; use of systemic chemicals; and restorative procedures, with black-and-white photographs of patients under treatment and of housing arrangements. Detailed descriptions and plans are provided for medical facilities, indoor and outdoor accommodation for convalescence, permanent housing for unreleasable birds, and breeding complexes. The McKeevers' success with Snowy and Saw-whet Owls breeding in captivity proves how much they have learned about the many physical and psychological difficulties involved in providing the necessary environment.

Behavioral problems such as with human imprinting and the training of captive-bred and rehabilitated birds for release are discussed, as well as provision of proper food, methods of feeding, and the maintenance of captive food supply. Such useful details as the keeping of records, "libraries" of feathers for study of the molts, etc., tape-recordings of vocalizations, are given as well as suggestions for how to go about establishing a similar foundation. Obviously this requires tremendous outlays of physical and financial resources and the author points out the absolute necessity of having interested and competent veterinary help available. She does not mention that permission must be obtained from provincial wildlife authorities before a captive raptor can be held. The lack of an index and a glossary of the many technical terms detracts from the convenience of the book.

On the premise that since most injuries to raptors are caused by man, Mrs. McKeever suggests it is up to man to do what he can to save and rehabilitate his victims. Anyone with the determination and resources to establish a foundation like the O.R.R.F. will find her book an indispensable source of information. It will also be of use to anyone confronted with a disabled bird of any species and the discussion of owls and their behavior makes absorbing reading.

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The Biogeochemistry of Blue, Snow and Ross' Geese

By Harold C. Hanson and Robert L. Jones. 1976. Southern Illinois University Press, Carbondale. 281 pp., illus. U.S. $15.

The main aim of this book is to propose a new technique — feather mineral pattern analysis — for distinguishing different populations of wild geese, and for relating them to particular breeding and molting areas. The flight feathers of geese were analyzed to find the concentrations of 12 different mineral elements. Birds from the same area varied only slightly in their feather mineral patterns, but there were huge differences in mineral patterns between birds from different areas. It was thus possible to distinguish birds from different areas by analyzing their flight feathers. The different patterns were not genetically determined, but depended on the levels of various minerals present in food at the time of feather growth, and thus on the local soil and bedrock. This in itself is a remarkable finding, as it cuts across the traditional view that animals precisely regulate the composition of their tissues, with little variation among individuals. It raises the questions whether other tissues vary as much as feathers in their mineral contents, or whether feathers act as dumping grounds for surplus mineral? Either way, if geese from different areas can be distinguished, then so, presumably can other birds, and perhaps some other animals. The findings also emphasize the prospects of monitoring pollutant levels by feather analysis, as has already been done to good effect for mercury in Sweden. The authors give the term 'biogeochemistry' to this new type of study, and are justified in thinking that it will interest biochemists, physiologists, and nutritionists, as well as ecologists.

The authors' chief interest in the technique is in its management possibilities. They claim that it promises to supplement, or in some cases, replace banding, as a means of establishing the origins of migrant and wintering geese. It should allow finer discrimination between sub-populations, and thus give more resolution in management. Whether these claims are justified remains to be seen, but the allocation of birds shot in winter to particular breeding or molting areas will presumably depend on having all these areas 'typed' beforehand with respect to feather mineral patterns. This is in itself a huge job, though considerable progress has already been made.

The book is nicely presented and well illustrated with many diagrams, maps, and photographs. I found the text interesting and thought-provoking, but would have welcomed much more information on the variation in mineral patterns between different feathers on the same bird, between different individuals in the same molting area, and between sex and age groups and years. There was also the disturbing observation that the mere washing of feathers for long periods in water removed some considerable mineral content. Only when these aspects have been fully explored can one put proper confidence limits on the ability to discriminate birds from different areas. One can only hope that this innovative book will stimulate more work on the same lines.

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BOTANY

North American Species of *Lactarius*

By L. R. Hesler and A. H. Smith. 1979. University of Michigan Press, Ann Arbor. ix 841 pp., illus. Cloth U.S. $25.

Mushrooms of the genus *Lactarius* are among the most conspicuous and colorful species of fungi. Some are ardently sought for food. In nature they are extremely important partners in symbiotic (i.e., mycorrhizal) associations with various woody plants. These fungi typically produce medium- to large-sized mushroom fruitbodies which characteristically exude a latex when the mushroom is cut or broken.

Despite their large size and beauty, which has attracted considerable interest by amateurs and professionals, a critical study of the North American species has been slow to develop (e.g., 45% of the 197 species in this book have been newly described since 1959 and principally by Hesler and Smith). The authors emphasize that "There is more to be done than has been done. With the vast expanses of Canada still almost completely unsampled, no reasonably complete *Lactarius* flora for North America can be written." The common *L. deliciosus* and the western *L. rubrilacteus* (a species formerly reported from

North America as *L. sanguifluus*) were not reported from Canada although they surely occur here. Nevertheless, 46 species are reported from Canada (i.e., Nova Scotia, Quebec, Ontario and one species each from Manitoba and British Columbia).

The book contains 39 pages of methods for studying fresh and dried specimens, keys to the six subgenera and the species, species descriptions, 249 drawings of spores, cystidia and tissues, 154 excellent black-and-white photographs of various mushrooms, and three appendices. Appendix I contains descriptions of 29 species and varieties not yet found in North America but expected to be part of the flora (*Lactarius flavidus*, number 73, from Japan and *L. pusillus*, number 147, from Europe should have been listed here rather than in the flora). The inclusion of the extralimital species in the keys would have facilitated their recognition in our flora. Appendix II contains 37 "excluded and doubtful species." Appendix III prepared by R. L. Homola and N. S. Weber illustrates basidiospores of many species in scanning electron micrographs and drawings. Access to the pictures in Appendix III is cumbersome because they are not referred to in the species descriptions; however, 48 additional drawings of basidiospores (Figure 202–249) are cited in the species descriptions.

In discussing the distribution of species in North America, the continent is divided into four "mushroom provinces." One "extending from Alaska to Labrador" (i.e., Canada) is not included in the discussion "because we lack a significant sample of the *Lactarius* flora of that country" of 8 675 000 km^2. The distribution of the species in Canada is sometimes vague (e.g., "in Canada" on p. 324 but no specimens are cited). Specimens are cited by province and collector's number, a form which equates a report from Nova Scotia with one from Ontario, which is 20 times larger, covers 15° of latitude, and contains three major forest types. The distribution is sometimes misleading. For example, the range of *L. deceptivus* is given as southern Canada but specimens are cited from Parc Chibougamau, Quebec (about 49° N); however, these boreal forest collections by David Malloch were inserted in the manuscript at the last minute. Throughout the book there are confusing anomalies between distribution and the specimens cited (e.g., the distribution of *L. tomentoso-marginatus* appears as Michigan but specimens are cited from Michigan, North Carolina, and Vermont).

This monograph, which is the biggest and best on the genus, will be a classic in mycological literature. The authors feel that it is a preliminary treatment but the foundation they have laid and the problems they pinpoint will facilitate further contributions. My comments have been, in part, directed toward stimulating interest in the Canadian flora. Despite the weak treatment of the Canadian flora (an irrelevant problem if the monograph were entitled *United States species of Lactarius*) this book will be indispensable in the study of our flora.

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Wildflowers of the North

By R. G. Bryan and M. E. Newton-White. 1978. Highway Book Shop, Cobalt, Ontario P0J 1C0. 215 pp., illus. $12.00.

North, to some, is a land of tundra, but to Bryan and Newton-White it is that part of Ontario and Quebec adjacent to Temagami and Lake Temiskaming. The flowers that are found there are, however, boreal species that are found over a wide range, and thus the book is of interest over a much wider territory.

The book is a combination of line drawings and hand printed text which blend together to give a most interesting presentation. This form of presentation makes the book a small coffee-table item, but it will also serve as an introduction to the flora of the region to both visitors and local residents. The about 380 species treated are described under the headings of growth habit, flowers, fruit, leaves, stem and root, and the habitat where they might be found, in a simple easily understood manner, but there is sufficient detail for recognition. Scientific names as well as both English and French names are given.

Included in the book are a short introduction, notes on plant propagation, an illustrated explanation of terms, a page on fun with flowers, and English, French and Latin indexes.

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ENVIRONMENT

Nature Detective

By Hugh Falkus. 1978.Victor Gollancz (Canadian distributor Clarke Irwin, Toronto). 256 pp., illus. $22.50.

Falkus is a true nature detective and much can be learned from his methodology. His observations and discussions of how to interpret the behavior of nocturnal or otherwise hard-to-observe animals through their tracks and signs provide instruction and insight to the most experienced naturalists. The photographs and interpretive captions alone make the book worthwhile. I spent many enjoyable hours trying to puzzle out the activities depicted in these excellent illustrations. Later, reading the captions it seemed so obvious. I am sure almost any field-naturalist or serious student of field ecology would enjoy and learn from a similar experience.

A knowledgeable amature naturalist, Falkus writes in a folksy style, often rambling into personal anecdotes and occasionally introducing technical discussions that many professional biologists would dispute, at least in part. His constant use of local common names leaves the reader who does not have extensive knowledge of British animals and natural history somewhat confused. The discussions of projects with many professional associates such as N. Tinbergen, however, often introduce a high standard of technical information and originality of ideas to offset this. The professional quality of the photography (Falkus is a professional nature-film producer) is superb.

The seasonal organization of his treatment of the Cumbrian coastal and countryside habitats provides a continuity to his sometimes colloquial and rambling style. The writing is at all times very enjoyable and highly readable. The observations on trout and salmon show why he is an acknowledged expert in this his favorite hobby. There did appear to me to be some obsession with many photographs of half eaten birds, broken eggs, and headless baby rabbits (to Falkus rabbits are nothing but a pest and as such he would advocate their extermination), but then one cannot illustrate such a book with animal tracks alone and much behavior can be learned from the remains of a kill.

I recommend this book as an enjoyable guide to how a field-naturalist can make the most out of casual observation skills during nature walks. It is, of course, highly recommended to anyone interested in or planning a nature tour of Falkus's own home district of Cumbria in Great Britain.

WILSON EEDY

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Life on Forty Acres: a saga of Australian rural life

By Barry P. Moore. 1978. Classey Limited (U.S.A.), 1015 Mockingbird Lane, San Marcos, California 92069. 184 pp., illus. U.S. $13.00.

Lovers of things Australian take note: Barry Moore's "Life on forty acres" is now available from E. W. Classey Ltd.

The "forty acres" of the title refers to Moore's country retreat in New South Wales just outside Canberra. The name of his retreat is Calosoma, reflecting his interest in Carabidae, and is pronounced Ca-lós-o-ma, reflecting his British background. The "life" of the title is partly autobiographical and partly the natural history of Calosoma observed through the trained eyes of a scientist in the heady first years of owning his own piece of Australian bush. In such a short period one cannot expect a "saga of Australian rural life," of course, but one does find an understanding of the biological processes in action and commentary on the fascinating (even to Australians) plants and animals of Calosoma. It is in these areas that Moore hits his stride, and, as an example, the chapter on "The Noble Gum" contains some very fluid prose in the description of sclerophyll forests and their lack of a litter fauna. The book ends with a brief discussion on the philosophy of conservation.

Not surprisingly, a book written by an "adopted Australian" will probably be most appreciated by the overseas visitor. Bound in electric blue and black like the Superb Blue Wren on the front cover, the 184 pages are liberally interspersed with Moore's own scraperboard illustrations. A selected bibliography includes further suggested reading and the many fine handbooks now available on the Australian flora and fauna.

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Analysis of Ecological Systems

Edited by David J. Horn, Rodger D. Mitchell, and Gordon R. Stairs. 1979. Ohio State University Press, Columbus. ix + 312 pp., illus. U.S. $27.50.

This book is a collection of nine papers from a 1977 biosciences colloquium sponsored by Ohio State University. The theme, analysis of ecological systems, is covered almost entirely from the systems-modelling standpoint, and in this sense the topics are treated in a theoretical rather than applied manner. Four of the chapters (1, 2, 8, 9) require of the reader a considerable mathematical background in order to relate the text to the equations used to illustrate the models. The other five chapters are more narrative. All of them present a clear introduction, discussion, and extensive literature citations. They are, therefore, useful reviews of each field covered, but I think would appeal more to the academic than the resource manager.

R. C. Lewonton leads off with a review of population fitness, survival, and optimality from a decidedly evolutionary viewpoint. Chapter 2, written by R. D. Mitchell and M. B. Williams refers, as the title suggests, to Darwinian analysis as the "new natural history." Drawing trends from species resource use and energy budget studies by field biologists, they propose a "strategy model" which supports Darwinian theory.

Chapter 3, by D. G. Embree, uses four species to illustrate the ecology of colonizing species. The setting is New Brunswick, and this is the only Canadian content in the book. E. R. Pianka et al. discuss in Chapter 4 the coexistence in the same environment of closely related species. In this case, niche segregation of desert lizards is used to illustrate competitive interactions and species packing models as they relate to the resource spectrum available. This is a long and complex chapter with which I had difficulty.

Chapter 5, by L. E. Gilbert, discusses insect–plant interactions from the standpoints of parasitism, predation, mutualism, and co-evolution. Then Gilbert puts this review in the context of theories developed to draw some generalities out of the data. The section on plants as islands provides an interesting model, and the area-distance relationships form a recurring theme throughout the book. Central place foraging theory is the subject of Chapter 6 by G. H. Orians and N. E. Pearson. The model relates energy requirements in foraging stategies to energy captured in preferred prey selected, and seems to me to be an important extension of the niche concept.

P. C. Miller's chapter on quantitative plant ecology (Chapter 7) does not discuss ordination, principle component analysis, or any other common quantitative treatment of vegetation community structure. Rather he discusses plant biomass and other production parameters in relation to environmental characteristics. This leads to a carbon balance theory which seems to fit plant succession and ecosystem points of view. In Chapter 8, R. G. Wiegert discusses models that simulate different characteristics of populations, such as the Lotka-Volterra predator–prey interaction and its refinements. Full recognition and discussion is given to the weaknesses of the assumptions of these models, and their limitations emerge in perspective. The last chapter covers parasitoid ecology and biological control. Various interaction models are presented, and the case of parasites of the alfalfa weevil is used to illustrate the chapter.

Recurring theoretical notions repeat throughout the book. It seems that discussions of ecological models always have some component of the late R. H. MacArthur's musings on species equilibria, *r* and *K* strategies and area-distance relations. As always, I look for a means of bridging the gap between theory and practice. This book is a long way from it. People who make day-to-day decisions affecting land use or wildlife on real landscapes need practical guides for the analysis of ecosystems and subsystems. It would be very useful if there was a companion volume designed for use by this audience rather than strict academics.

B. WILKES

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An Introduction to Systems Analysis: with ecological applications

By John N. R. Jeffers. 1978. Edward Arnold, London (Gage, Agincourt, Ontario). 198 pp. $23.10 paper.

This book should be seen by those interested in scanning the mathematical techniques used by decision-makers to predict courses of action for broad research programs. It is a helpful introduction for those who want to know what a systems analyst may contribute to ecology. Mathematical techniques are used to construct models that more closely simulate realistic conditions because of the larger number of variables in the model. Quite a bit of space is used in defining terminology. In the author's words, "Systems analysis... is a broad research strategy... [where an] orderly and logical organization of data and informa-

tion [is put] into models, followed by rigorous testing.... " Dynamic, matrix, multivariate, optimization, and stochastic models are each discussed in their own chapters.

Despite the author's comments in the Preface, the mathematics are somewhat complex in some chapters (6 and 7) but are explained in a way most naturalists can understand without too much statistical training. In short, almost anybody can gain some understanding of the theories and practices of the systems analyst by reading this book. To construct models with systems analysis theory, however, one must know how to run a computer.

Although this book reads with facility, has relatively few typographical errors, and a good subject index, there are many areas that diverge from the main point. The dynamic modelling chapter (3) is inarticulate and there are misprints in some of the listed programs (cf., p. 42). Some of the matrices in the matrix modelling chapter (4) are incorrect (cf., p. 55). In other chapters (1, 2, 8, and especially 9), I found myself reading two or three successive pages of common sense. It is unfortunate that the price of this book is so high.

Since Jeffers uses publications where raw data were not collected with the systems analyst in mind, many of the examples used to explain systems techniques could mislead an ecologist into feeling that much of systems analysis theory is retrospective. In reality, the data base needed for systems analyses is so large that few system studies have been attempted.

Overall, this book makes one understand that the field of ecological systems analysis is just beginning and at present is too far ahead of its time to be useful. At any rate, anybody who feels that any portion of systems analysis may be useful should read the multivariate modelling and optimization chapters (6 and 7), perhaps the best chapters in the book.

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PBB: an American tragedy

By Edwin Chen. 1979. Prentice-Hall, Englewood Cliffs, New Jersey. 330 pp.

In 1973, the Michigan Chemical Corporation mixed up its supplies of Nutrimaster (magnesium oxide) with those of Firemaster (a fire retardant chemical composed basically of polybrominated biphenyl, PBB). By accident, several thousand pounds of PBB were fed to dairy cows all over Michigan. Many cows sickened and died, their carcasses being sold for meat; others produced contaminated milk which was shipped for a year throughout the state. By the time the mix-up was detected, virtually everyone in Michigan had been poisoned.

This accident was a terrible one, but the response from government, university, and corporation officials was far worse. To begin with, no one knew who was responsible for dealing with the catastrophe; it could not be conveniently classed as an epidemic, nor as an "act of God" like a tornado or a flood. After the blunder became public knowledge, officials continued to ignore or misread incoming relevant information. Some ridiculed the farmers, accusing them of harming their own registered herds by their poor farm practices, and of malingering when they complained of their own ill health. Instead of acting to contain the contaminant, the government tried to suppress the evidence so that human exposure to the chemical was prolonged by years. Already experts are predicting a sharp rise in cancer rates in Michigan 15 or 20 years from now.

This book is an important one not only because it serves as an example of how not to handle an emergency, but because it draws attention to the dangers of chemical contaminants now present in the environment of North America. We know enough about dioxin and Kepone and chemicals from the Love Canal in New York State to realize their potential hazard. What other pollutants may soon be poisoning us? Will we learn enough from scientists and journalists like Chen to be able to react sensibly to them? Or might we possibly learn not to pollute in the first place? Our future may depend on it. If governments in North America are persuaded by this book to act responsibly and openly, the book will have served its purpose well.

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MISCELLANEOUS

Elements of Park and Recreation Administration

Doell, Charles E. and Louis F. Twardzik. 1979. 4th edition. Burgess Publishing Company, Minneapolis. vi + 367 pp. U.S. $13.95.

The fourth edition of this book offers little appreciable change in approach from previous editions. The discourse emphasizes the social-service role of recreational lands and parks. Like its predecessors, this edition is intended as a basic primer for aspiring park managers.

Although the organization and content of specific chapters have been modified, overall the format and content parallel the third edition. Three broad subject areas are covered. The first section provides a review of the philosophy and history of recreation, a review which has been expanded considerably over earlier editions. The second section provides a synopsis of recreational land resources of municipal, state, and federal jurisdictions in the United States. The latter chapters review unifying administrative principles common to all jurisdictions: staffing, financial management, policy formulation, planning, facility development, operations, and other functions.

Major limitations issue from the social-service focus of the book. The virtual omission of discussion about environmental and wildlife conservation, objectives especially prevalent to some park systems, results in a distorted and simplified treatment regarding the administration of these parklands. For example, the concepts of classification and zoning as tools to impose appropriate levels of use and resource protection receive too little discussion. An oversimplified outline of park planning ensues, leaving the reader with the impression that a planner armed with a few maps can develop a park plan. In reality, the planning of parklands in many jurisdictions are multidisciplinary approaches which incorporate environmental and wildlife concerns as well as recreational interests. To treat any of these concerns in isolation is dangerous.

Although it is the authors' prerogative to establish limits on the breadth of the subject matter that they address, it is equally their responsibility to qualify their presentation within the broader subject area with which they are dealing. In my opinion, there is a need to balance the recreation bias in this book with more discussion about other facets of resources management. At least a chapter should be devoted to environmental management and wildlife conservation, as these are viable objectives which are not mutually exclusive of recreation administration. In addition, suggested references on these topics would be a responsible service to readers to insure the broadest possible initiation to the administration of parklands.

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NEW TITLES

Zoology

Africa's flamingo lake. 1979. By Francine Jacobs. Morrow, New York. 80 pp., illus. U.S. $5.95.

Aquatic miniatures. 1979. Edited by Don Earnest. Silver Burdett, Morristown, New Jersey. 128 pp., illus. U.S. $6.93.

Aquatic oligochaete biology. 1980. Edited by Ralph O. Brinkhurst and David G. Cook. Proceedings of a symposium, Sidney, British Columbia, May 1979. Plenum, New York. 530 pp. U.S. $55 (plus 20% foreign handling).

†**Arthropods of Polar Bear Pass, Bathurst Island, arctic Canada.** 1980. By H. V. Danks. Syllogeus Number 25. National Museum of Natural Sciences, Ottawa. 68 pp. Free.

Audubon's birds of America. 1979. By George Dock, Jr. Abram, New York. 170 pp., illus. Cloth U.S. $19.95; paper U.S. $7.95.

Australia's animals discovered. 1980. By P. Stanbury and G. Phipps. Pergamon Press, Elmsford, New York. 128 pp., illus. U.S. $14.90.

Avian community structure of six forest stands in La Mauricie National Park, Quebec. 1980. By J.-L. DesGranges. Occasional Paper Number 41. Canadian Wildlife Service, Ottawa. 34 pp., illus.

†**Biology of communication.** 1980. By D. Brian Lewis and D. Michael Gower. Halsted Press (Wiley), New York. 239 pp., illus. U.S. $27.95.

†**Biology of the Harbor Seal, *Phoca vitulina*, in eastern Canada. 1979.** By J. Boulva and I. A. McLaren. Fisheries Research Board of Canada Bulletin 200. Supply and Services Canada, Hull. 24 pp., illus. $3 in Canada; $3.60 elsewhere.

Birds and how they function. 1979. By Philip S. Callahan. Holiday House, New York. 156 pp., illus. U.S. $8.95.

Catalogue of the egg collection of Norval Gray Jones, (1891–1956), London, Ontario. 1980. By W. W. Judd. Phelps, London. $3.

The complete encyclopedia of the animal world. 1980. By David M. Burn. Octopus (Doubleday, Toronto). 400 pp., illus. $35.

A country-lover's guide to wildlife: mammals, amphibians and reptiles of the northeastern United States. 1979. By Kenneth A. Chambers. Johns Hopkins University Press, Baltimore. xviii + 228 pp., illus. U.S. $14.95.

Echinoderms: past and present. 1980. Edited by M. Jangoux. Balkema, Rotterdam. 480 pp. Hfl 80.

Hawk lady. 1980. By Stellanie Ure. Doubleday, Toronto. Illus. $15.95.

Hawks and owls of North America: a complete guide to North American birds of prey. 1979. By Donald S. Heintzelman. Universe, New York. 195 pp., illus. U.S. $18.50.

Herbivores: their interaction with secondary plant metabolites. 1979. Edited by G. A. Rosenthal and D. H. Janzen. Academic Press, New York. xvi + 718 pp., illus. U.S. $59.50.

Lobsters, crabs, shrimps and their relatives. 1979. By R. Headstrom. Barnes, South Brunswick, New Jersey. 144 pp., illus. U.S. $14.50.

†**Mammals of the Edmonton area.** 1979. By Hugh C. Smith. Natural History Occasional Paper Number 2. Provincial Museum of Alberta, Edmonton. 34 pp. Paper $1.25.

†**The park buffalo.** 1979. By Sheilagh C. Ogilvie. National and Provincial Parks Association of Canada, Calgary. 68 pp., illus. $4.95 plus 50¢ postage.

Philippine lizards of the family Gekkonidae. 1978. By W. C. Brown and A. C. Alcala. Natural Science Monograph Series Number 1. Silliman University, Dumaguete City, Philippines. 146 pp., illus. U.S. $6.

Stillwater trout. 1980. By John Merwin. Doubleday, Toronto. Illus. $16.95.

Stoneflies. 1980. By Carl Richards, Doug Swisher, and Fred Arbona. Doubleday, Toronto. $14.95.

†**Tertiary mammals of Saskatchewan, part V: the Oligocene entelodonts.** 1980. By Loris S. Russell. Life Sciences Contributions 122. Royal Ontario Museum, Toronto. 42 pp. $2.75.

Threatened deer — proceedings of a working meeting of the deer specialist group of the survival service commission. 1979. By the International Union for Conservation of Nature and Natural Resources. IUCN, Morges, Switzerland. 434 pp.

The trout and the fly. 1980. By Brian Clarke and John Goddard. Doubleday, Toronto. illus. $16.95.

†**Tuna and billfish: fish without a country.** 1979. By James Joseph, Witold Klawe, and Pat Murphy. Inter-America Tropical Tuna Commission, La Jolla, California. 46 pp., illus. U.S. $7.95.

Wildlife of the forests. 1979. By Ann Sutton and Myron Sutton. Abrams, New York. 231 pp., illus. U.S. $16.95.

Wildlife of the mountains. 1979. By Edward R. Ricciuti. Abrams, New York. 232 pp., illus. U.S. $16.95.

The world of a beehive. 1979. By John Powell. Faber and Faber, Salem, New Hampshire. 143 pp., illus. U.S. $9.95.

Botany

Annual review of plant physiology. 1979. Edited by W. R. Briggs, P. B. Green, and R. L. Jones. Volume 30. Annual Reviews, Palo Alto, California. xii + 672 pp., illus. U.S. $17.

†**A catalogue of the marine algae of the Canadian Arctic.** 1980. By R. K. S. Lee. Publications in Botany Number 9. National Museum of Natural Sciences, Ottawa. 82 pp. Free.

†**Checklist of the mosses of Canada.** 1980. By the Canadian Botanical Association Bryophyte Checklist Committee, R. R. Ireland, Chairman. Publications in Botany Number 8. National Museum of Natural Sciences, Ottawa. 75 pp. Free.

Checklist of United States trees (native and naturalized). 1979. By Elbert L. Little, Jr. Agriculture Handbook Number 541. United States Department of Agriculture, Washington. 375 pp. U.S. $10.

Common and botanical names of weeds in Canada. 1980. By Jack F. Alex, Richard Cayouette, and Gerald A. Mulligan. Revised edition. Agriculture Canada Publication Number 1397. Supply and Services Canada, Hull. 132 pp. $5.75 in Canada; $6.90 elsewhere.

†**Evolution of archeopyle and tabulation in rhaetogonyaulacinean dinoflagellate cysts.** 1980. By Gunter Dorhofer and Edward H. Davies. Life Sciences Miscellaneous Publications. Royal Ontario Museum, Toronto. 91 pp., illus. $5.50.

Flora of Ceylon. 1980. Edited by F. R. Fosberg and M. D. Dassanayake. Balkema, Rotterdam. 6 volumes to be published 1980–1983 totalling 3000 pp. Hfl 48/volume.

Grasses of Ontario. 1980. By William G. Dore and J. McNeill. Agriculture Canada Monograph 26. Supply and Services Canada, Hull. 566 pp. $12 in Canada; $14.40 elsewhere.

Heathlands and related shrublands. Part A: descriptive studies. 1979. Edited by R. L. Specht. Ecosystems of the World, Volume 9A. Elsevier, New York. xiv + 498 pp. U.S. $83.

Heathlands and related shrublands. Part B: analytical studies. 1980. Edited by R. L. Specht. Ecosystems of the World, Volume 9B. Elsevier, New York. 360 pp. U.S. $83.

The impatiens of Africa. 1980. By C. Grey-Wilson. Balkema, Rotterdam. 240 pp., illus. Hfl 110.

Knowing your trees. By G. H. Collingwood and W. D. Bush. American Forestry Association (distributed by Scribner's, New York). 389 pp., illus. U.S. $14.95.

†**The rare vascular plants of Manitoba.** 1980. By David J. White and Karen L. Johnson. Syllogeus Number 27. National Museum of Natural Sciences, Ottawa. English; 52 pp. French; 53 pp. + map figures. Free.

The soil-root interface. 1979. Edited by J. L. Harley and R. S. Russell. Proceedings of a symposium, Oxford, England, March 1978. Academic Press, New York. xx + 448 pp., illus. U.S. $32.50.

Succulent flora in southern Africa. 1980. By Doreen Court. Balkema, Rotterdam. 300 pp., illus. Hfl 140.

***Vascular flora of the southeastern United States, Volume 1: Asteraceae.** 1980. By Arthur Cronquist. Edited by A. E. Radford. University of North Carolina Press, Chapel Hill. 320 pp. U.S. $25.

†**Vascular plants of Glacier National Park, British Columbia, Canada.** 1980. By Erich Haber and James H. Soper. Syllogeus Number 24. National Museum of Natural Sciences, Ottawa. 34 pp. Free.

Environment

Alaska's great interior. 1980. By Alaska Northwest Publishing, Edmonds, Washington. 128 pp., illus. U.S. $11.95.

A bibliography of Canadian climate, 1972–1976. 1979. By M. K. Thomas and D. W. Phillips. Supply and Services Canada, Hull. 135 pp. $4 in Canada; $4.80 elsewhere.

Canada's northlands. 1979. By M. J. Romaine and G. R. Ironside. Ecological Land Classification Series Number 0. Proceedings of a workshop, Toronto, April 1974. Lands Directorate, Environment Canada, Ottawa. 124 pp. Free.

Canada's special resource lands: a national perspective of selected land uses. 1979. By Wendy L. Simpson et al. Lands Directorate Map Folio Number 4. Supply and Services Canada, Hull. 232 pp., illus. (88 maps). $12 in Canada; $14.40 elsewhere.

†**Climate change in Canada.** 1980. Edited by C. R. Harington. Syllogeus Number 26. National Museum of Natural Sciences, Ottawa. 246 pp. Free.

The complete guide to backpacking in Canada. 1980. By Elliott Katz. Doubleday, Toronto. illus. Cloth $14.95; paper $8.95.

Ecology and coal resource development. 1979. Edited by Mohan K. Walie. Pergamon Press, Elmsford, New York. 1069 pp. U.S. $135.

Ecology of the Wadden Sea. 1980. Edited by W. J. Wolff. Balkema, Rotterdam. 1300 pp. in 3 volumes. Hfl 95.

Ecology versus politics in Canada. 1979. Edited by William Leiss. University of Toronto Press, Toronto. 282 pp.

Energy and environmental balance. 1980. By E. F. Murphy. Pergamon Press, Elmsford, New York. 250 pp. U.S. $27.50.

†**Environmental planning resource book.** 1980. By Reg Lang and Audrey Armour. Multiscience Publications, Montreal. 355 pp., illus. $15.50 (plus postage $1.50 in Canada; $2.50 elsewhere).

Erosion and environment. 1980. By M. Holy. Pergamon Press, Elmsford, New York. 266 pp., illus. U.S. $43.50.

Handbook of climatological data sources of the Atmospheric Environment Service. 1979. By D. W. Phillips. Supply and Services Canada, Hull. 169 pp. $10 in Canada; $12 elsewhere.

Introduction to forest biology. 1979. By Harold W. Hocker, Jr. Wiley, New York. xii + 467 pp., illus. U.S. $21.95.

Lake management. 1980. By S. E. Jorgensen. Pergamon Press, Elmsford, New York. 180 pp., illus. U.S. $28.60.

The living river: a fisherman's intimate profile of the Madison River watershed — its history, ecology, lore and angling opportunities. 1979. By Charles E. Brooks. Doubleday, Garden City, New York. 207 pp., illus. U.S. $17.50.

Man and his environment, volume 3. 1980. Edited by M. F. Mohtadi. Proceedings of the Third International Banff Conference on Man and His Environment, May 1978. Pergamon Press, Elmsford, New York. 256 pp. U.S. $44.

†**Natural resource conservation: an ecological approach.** 1980. By Oliver S. Owen. Third edition. Macmillan, New York. 883 pp., illus. U.S. $19.95.

†**Noise in the human environment.** 1979. By the Environment Council of Alberta, Edmonton. Two volumes. Free.

Parks Canada policy. 1979. By Conservation Service. Parks Canada, Hull. 69 pp. Free.

Polluted rain. 1980. Edited by T. Y. Toribara, M. W. Miller, and P. E. Morrow. Environmental Science Research Volume 17. Plenum, New York. 500 pp. U.S. $49.50 (plus 20% foreign handling).

Resources, environment and population: the nature of future limits. 1979. By R. G. Ridker and E. W. Cecelski. Population Reference Bureau, Washington. U.S. $1.50.

Theory of population genetics and evolutionary ecology: an introduction. 1979. By J. Roughgarden. Macmillan, New York. xii + 634 pp., illus. U.S. $24.95.

Voyageur country: a park in the wilderness. 1979. By Robert Treuer. University of Minnesota Press, Minneapolis. xiv + 173 pp., illus. U.S. $10.95.

Water quality interpretive report, Ontario, 1967–1977. 1979. Edited by R. N. McNeely. Inland Waters Directorate, Environment Canada, Ottawa. 67 pp., illus. Free.

Water quality source book: a guide to water quality parameters. 1979. By R. N. McNeely, '. P. Neimanis, and L. Dwyer. Inland Waters Directorate, Environment Canada, Ottawa. 89 pp., illus. Free.

*__We are the targets: the story of environmental impacts.__ 1980. By Harold McKenna, Jr., Richards Rosen Press, New York. vi + 115 pp. U.S. $7.97.

Wild habitats. 1979. By Aleta Karstad. Scribner's, New York. 144 pp., illus. U.S. $12.95.

Wild things. 1979. By Dion Henderson. Tamarack, Madison, Wisconsin. 93 pp., illus. U.S. $7.95.

Miscellaneous

Biological identification: the principles and practice of identification methods in biology. 1979. By Richard J. Pankhurst. University Park Press, Baltimore. viii + 104 pp., illus. Paper U.S. $9.95.

Discover archaeology: the amateur's guide to the tools and techniques of archaeological field work. 1980. By George Sullivan. Doubleday, Toronto. illus. $13.50.

The integral urban house: self-reliant living in the city. 1979. By the Fallones Institute. Sierra Club, San Francisco. 494 pp. U.S. $12.95.

Land use programs in Canada: Yukon Territory. 1979. By D. K. Redpath. Supply and Services Canada, Hull. 303 pp., illus. $3 in Canada; $3.60 elsewhere.

Margins for survival: overcoming political limits in steering technology. 1979. By Edward Wenk, Jr. Pergamon Press, Elmsford, New York. 193 pp. Cloth U.S. $22; paper U.S. $10.

The 1979 sun catalog. 1979. By Solar Usage Now, Bascom, Ohio. 288 pp., illus. Paper U.S. $2.

Remote sensing application in agriculture and hydrology. 1980. Edited by Georges Fraysse. Proceedings of a conference, Ispra, Italy. Balkema, Rotterdam. 510 pp., illus. Hfl 142.

*Assigned for review.
†Available for review.

Index to Volume 94

Compiled by W. HARVEY BECK

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Instructions to Contributors

Content

The Canadian Field-Naturalist is a medium for the publication of scientific papers by amateur and professional naturalists or field-biologists reporting observations and results of investigations in any field of natural history provided that they are original, significant, and relevant to Canada. All readers and other potential contributors are invited to submit for consideration their manuscripts meeting these criteria. As the journal has a flexible publication policy, items not covered in the traditional sections (Articles, Notes, Letters, News and Comment, and Book Reviews) can be given a special place provided they are judged suitable. Readers are encouraged to support regional, provincial, and local natural history publications as well by submitting to them their reports of more restricted significance.

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Please submit, in either English or French, three complete manuscripts written in the journal style. The research reported should be original. It is recommended that authors ask qualified persons to appraise the paper before it is submitted. Also authors are expected to have complied with all pertinent legislation regarding the study, disturbance, or collection of animals, plants or minerals.

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Although we prefer the names of journals in the Literature Cited to be written out in full, these may be abbreviated following the **Serial Sources for the BIOSIS Data Base**, published yearly by BioSciences Information Service, Philadelphia, Pennsylvania 19103. Unpublished reports should not be cited here. Next list the captions for figures (numbered in arabic numerals and typed together on a separate page) and present the tables (each titled, numbered consecutively in arabic numerals, and placed on a separate page). Mark in the margin of the text the places for the figures and tables.

Extensive tabular or other supplementary material not essential to the text, typed neatly and headed by the title of the paper and the author's name and address, should be submitted in duplicate on letter-size paper for the Editor to place in the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2. A notation in the published text should state that the material is available, at a nominal charge, from the Depository.

The **Council of Biology Editors Style Manual**, 4th edition (1978) available from the American Institute of Biological Sciences, is recommended as a guide to contributors. **Webster's New International Dictionary** and le **Grand Larousse Encyclopédique** are the authorities for spelling.

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